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NOISE CALCULATION PROCEDURES CONTAINED IN THE MOA RANGE NOISEMAP (MR NMAP) COMPUTER PROGRAM

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This technical report has been reviewed and is approved for publication.

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13. ABSTRACT *(Maximum 200 words)*
MRNMAP is the core module of the MOA-Range NOISEMAP (MR_NMAP) program for computing noise in military airspace. It is a collection of "building block" noise models that model the noise characteristics for the way planes fly in military airspace. There are two general representations: broadly distributed operations as generally occur in MOAs and Ranges, and distributed parallel tracks as occur on MTRs and in target areas. The calculations in MR_NMAP are based on a USAF dataset of measured aircraft noise levels called NOISEFILE. The program calculates standard noise metrics of L_{dnmr}, L_{dn}, CNEL, L_{eq}, SEL, and L_{max}. MR_NMAP's output is in the form of tables of noise levels and a grid file that is used with NMPLOT to draw the noise contours. A companion program called MROPS ("MOA-Range Operations") allows the user to draw the airspace, specify areas of high/medium/low activity levels, and draw specific flight tracks such as bombing runs and MTRs. This report describes the noise model and the algorithms contained in MR_NMAP. A separate report, WR 94-12, "Military Operating Area and Range Noise Model MR_NMAP, User's Manual", gives user instructions for MROPS and MR_NMAP.

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1.0 INTRODUCTION

A research program has been conducted to develop noise models for predicting the noise environment under Military Operating Areas (MOAs), Military Training Routes (MTRs), and Ranges. These models have been implemented in a computer program called MRNMAP ("MOA-Range NoiseMAP"). This report describes the technical basis for these noise models, the implementation of the models in MRNMAP, and the measurements that have been used to validate MRNMAP predictions.

The first chapter describes MRNMAP's organization and the noise models contained in the program. Section 1.1 gives an overview of the program organization. Section 1.2 describes the calculating procedures and gives a explanation on the different models found in MRNMAP. Section 1.3 explains some of the program limitations.

1.1 Overview

MRNMAP is a PC-based computer program that calculates noise levels under Military Operating Areas (MOAs), Military Training Routes (MTRs), and Ranges. These levels are output as contours or in a tabular format, and are suitable for inclusion in Environmental Impact Statements and Environmental Assessments. MROPS ("MOA-Range OPerationS") is a companion interface program that facilitates defining the airspace, specifying the aircraft types and operations, and controlling the computational features of MRNMAP. MROPS and MRNMAP, together with the contouring program NMPLOT, form a complete package for evaluating noise impacts under military airspace.

Figure 1-1 shows the organization of the three modules which form the software package. The first module is MROPS. This is an interactive, Windows-based program which is the primary user interface. A series of menus and entry forms prompt the user for all required information. The software provides for the data to be entered in tabular format. Geometric data such as airspace boundaries and flight tracks may alternatively be entered graphically using CAD-like features. The user may also draw upon databases which define all existing airspace components. This module manages data for various assessments and alternatives, and can be used to run the other modules.

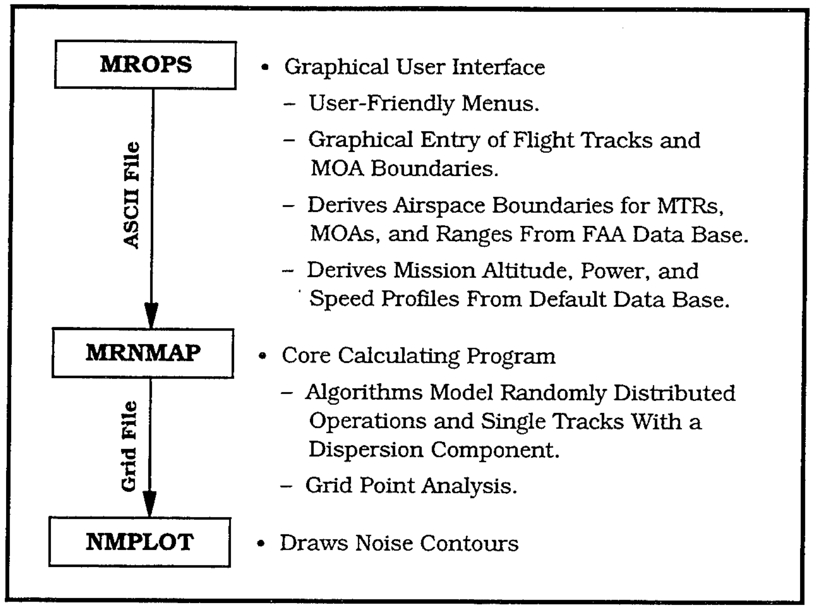


Figure 1-1. Overview of Computer Programs.

MRNMAP, the second module, performs the noise calculations. It is a collection of building block noise models. All of the models are based on NOISEMAP technology, which embodies the physics of aircraft noise generation and propagation. Each model is structured so as to apply this technology to the way that aircraft fly in military airspace, and is optimized for the appropriate type of operation. From a modeling perspective, there are two main categories of aircraft operations: distributed operations, as found in MOAs, and track operations, as found on MTRs and target approaches. MRNMAP is structure to accommodate additional and/or updated more noise models as the technology advances and is refined.

The user generally will not interact with MRNMAP, but will access it through MROPS. When used in this manner, MRNMAP runs as a self-contained process using a data file created by MROPS for input. To simplify the use by those with a specific need to run MRNMAP directly, to facilitate "chronicle" style auditing, and to allow use of MRNMAP with other software (such as the Air Force's ASAN system), the input data file is in a ASCII format with a well-defined, readable structure. As output, MRNMAP creates two files: (1) a .TXT file (ASCII) which contains airspace, mission, and operations data, as well as the computed noise levels in tabular format, and (2) a .GRD file (binary) which contains the airspace boundaries and the noise level contours.

The third module, NMPLOT, is the Air Force's standard noise contour plotting program. The user will normally access NMPLOT through MROPS, but may interact with it directly to specify the desired format of the graphical output. NMPLOT process the .GRD file output by MRNMAP.

User instructions for the MRNMAP system of programs are presented in Reference 1. The current report describes the noise models, which are implemented in the core MRNMAP module. For the remainder of this report, MRNMAP refers to that module.

1.2 Noise Modeling Approach

1.2.1 Organization

MRNMAP's organization is shown in Figure 1-2. The arrows indicate the order of access to the various routines and the overall flow of the program. This section provides an overview of the program's organization and computational procedures. Details of the noise models are discussed in subsequent sections.

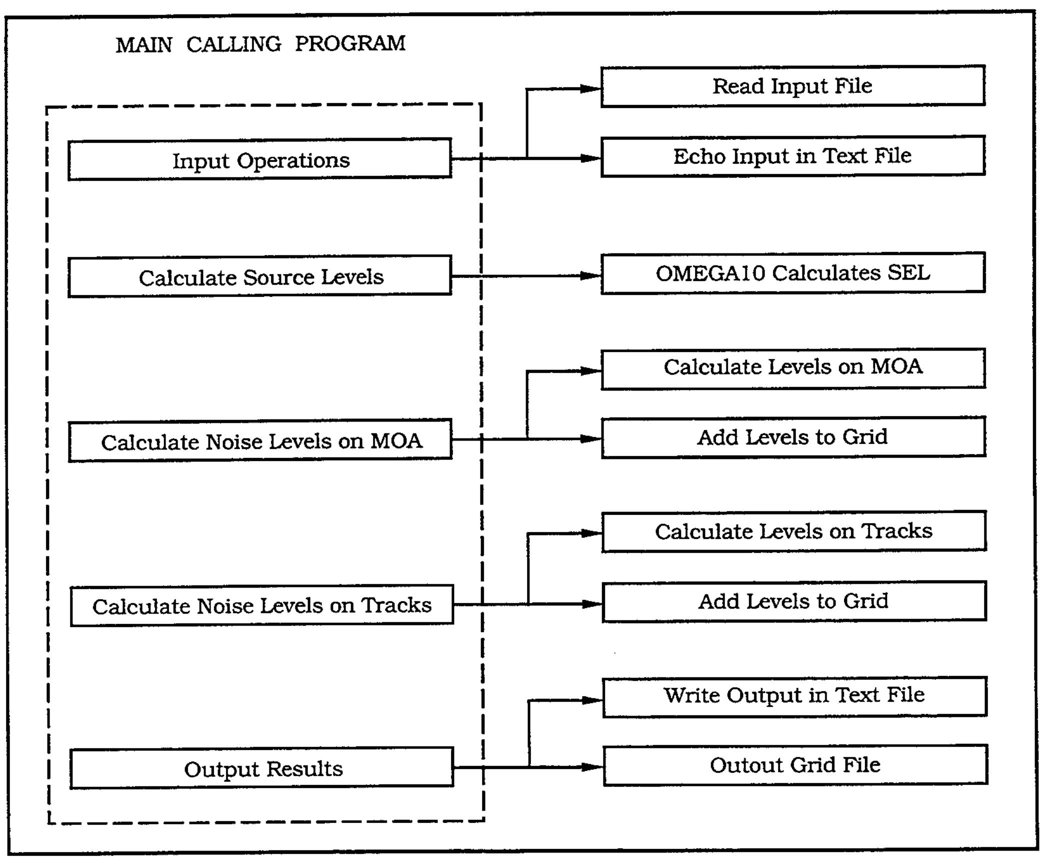


Figure 1-2. Program Organization.

The program begins with MRNMAP reading the input file, and checking the file for errors in data structure and errors. Section 3.0 contains a description of the file format. If an error is detected, the program will display the message "Process Stopped" and writes an error message followed by a line number at the bottom of the text (.TXT) file. The line number points to the line of text that generated the error. When no errors are detected, MRNMAP writes a text file that echoes the input.

Next, MRNMAP calculates the SEL values using the Air Force NOISEFILE acoustical data set. NOISEFILE contains the measured one-third octave data sets obtained from controlled flyovers at the prescribed power and speed settings. MRNMAP calls a subroutine version of the OMEGA10[2] program, which reads the NOISEFILE data set and calculates the SEL for the specified aircraft settings. This process uses the same physical models as the Air Force's NOISEMAP program.[3] These levels are returned to MRNMAP and are then used in all future noise calculations.

Once the SEL values have been determined, MRNMAP calculates the noise due to distributed aircraft operations. The program first constructs a table of SEL levels versus ground distance based on the aircraft operating at an equivalent acoustical altitude. Then the distance separating the noise contours, as determined from the table, is multiplied by the time spent in the airspace and the actual speed of the aircraft. The results is the area of the noise contours swept out under the airspace. The energy-average is calculated by normalizing this area with respect to the total airspace area and summing over all the contours (see Figure 1-3). At the edges of the airspace, where operations end, the noise is calculated using a model that tapers off the number of operations. Details of this model are described in Section 2.3. The model is based on tracking data collected from military aircraft training in MOAs and Ranges.

Next, MRNMAP calculates the noise levels under the tracks. The track algorithms contained in MRNMAP closely approximates those algorithms in the USAF NOISEMAP and ROUTEMAP[4] computer programs. MRNMAP models three track scenarios: (1) tracks that follow a single dominant track, (2) tracks that are distributed as a Gaussian distribution of line sources having the same standard deviation and altitude at either end of the line segment, and (3) tracks that are distributed as a Gaussian distribution of line segments having a standard deviation

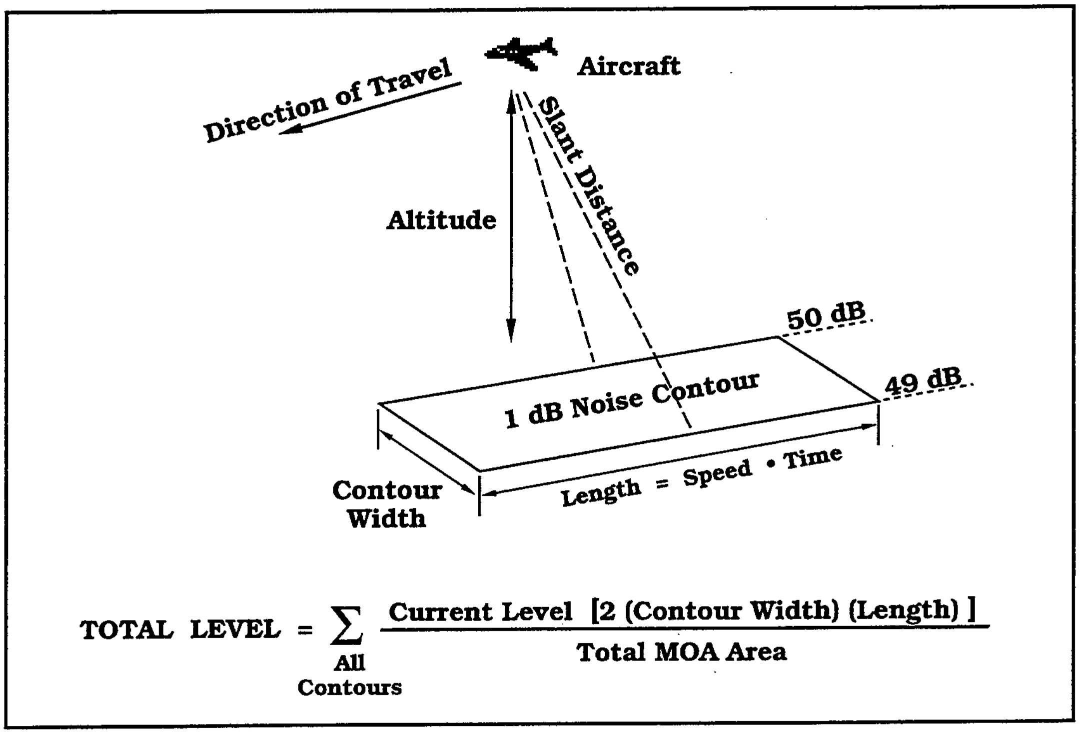


Figure 1-3. Algorithm Used to Calculate Noise From Distributed Operations.

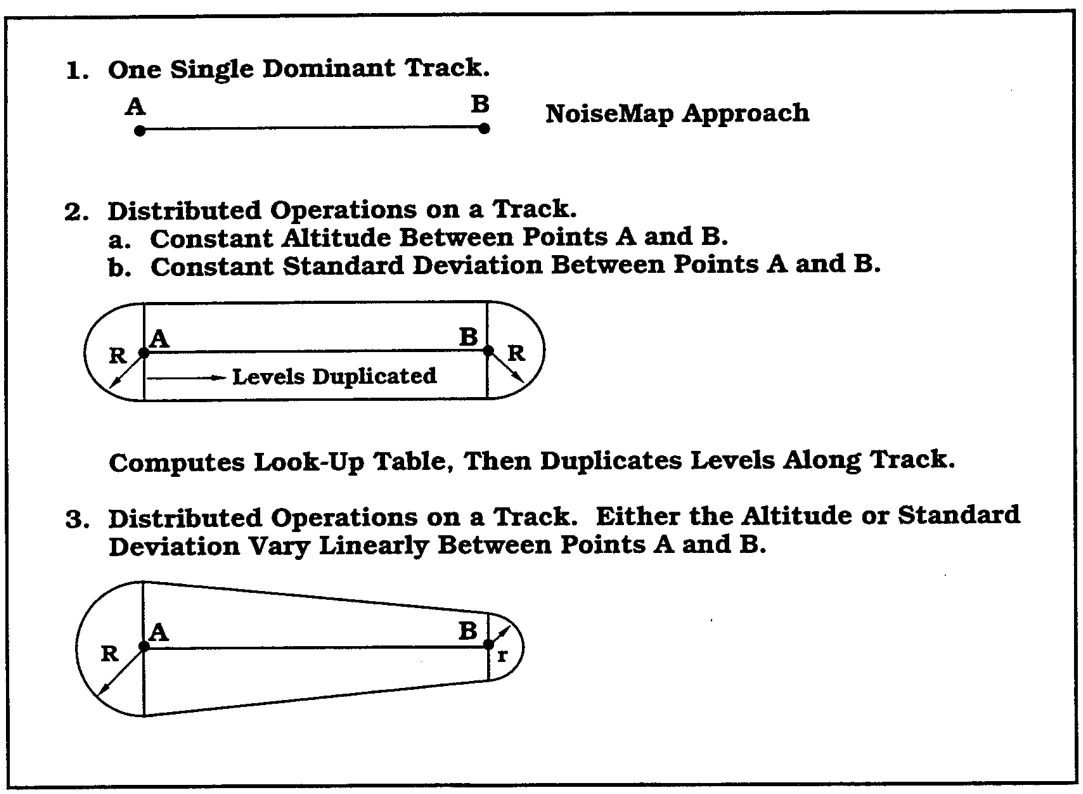


Figure 1-4. Algorithms Used to Calculated Noise From Operations on a Track.

and altitude that are not the same at either end of the line segment (see Figure 1-4). Turns are modeled as connecting line segments using algorithms similar to the ones used in the FAA's Integrated Noise Model (INM).

Following the noise calculations, MRNMAP outputs a summary of the noise levels for the MOAs, Ranges, and tracks to a text file. Included in the text file are the noise levels and number of events over a pre-specified level for each airspace component. Reporting the number of events over a pre-specified level is not part of quantitative impact analysis, but is very useful when describing the noise environment to community planners and the general public.

The last step is writing a binary grid file containing the noise levels. The file is read by NMPLOT when displaying the noise contours.

The following subsections describe the noise models contained inside MRNMAP.

1.2.2 Equivalent Acoustical Altitude

The equivalent acoustical altitude (EAA) is the constant altitude at which an aircraft must fly to produce the same noise level for a distributed altitude profile. Using the EAA in place of the altitude profile in the noise calculations significantly increases the computational speed by reducing the number of calculations MRNMAP makes.

Calculating the EAA in MRNMAP is done as a two-step process. The first step sums the noise level directly under the aircraft using the altitude distribution appearing under the MISSION keyword. The summing process begins at the floor of the airspace and continues up to the ceiling. The result is the total noise level under the track. In the second step, the program uses this noise level to look up the equivalent altitude from the SEL tables. This becomes the equivalent acoustical altitude and its value replaces the altitude distribution in subsequent calculations.

1.2.3 MOA Edge Model

Noise modeling in MOAs and Ranges assumes the operations within are uniformly distributed. In Section 2.3 it will be shown that, near a MOA edge, the

operations decrease at a linear rate. A sketch of the MOA edge is shown in Figure 1-5. The noise level near the MOA edges is calculated using the relation:

$$\text{Grid Point Level} = \text{Energy Average Level} + 10\log_{10}(d/S) \qquad (1\text{-}1)$$

where d is the closest distance to the MOA edge, and S is the standoff distance. The value of the standoff distance, is shown in Section 2.3 to vary between 1 and 5 nautical miles and its value is dependent on the MOAs size, shape, and purpose. The energy-average level is the level calculated assuming all the operations are uniformly distributed. This formulation has the effect of lowering the noise levels at the MOA edges thus reducing the total acoustical energy. To preserve the total acoustical energy an adjustment is made to all the grid points contained within the MOA so that the total noise level equals the noise level calculated assuming uniformly distributed operations.

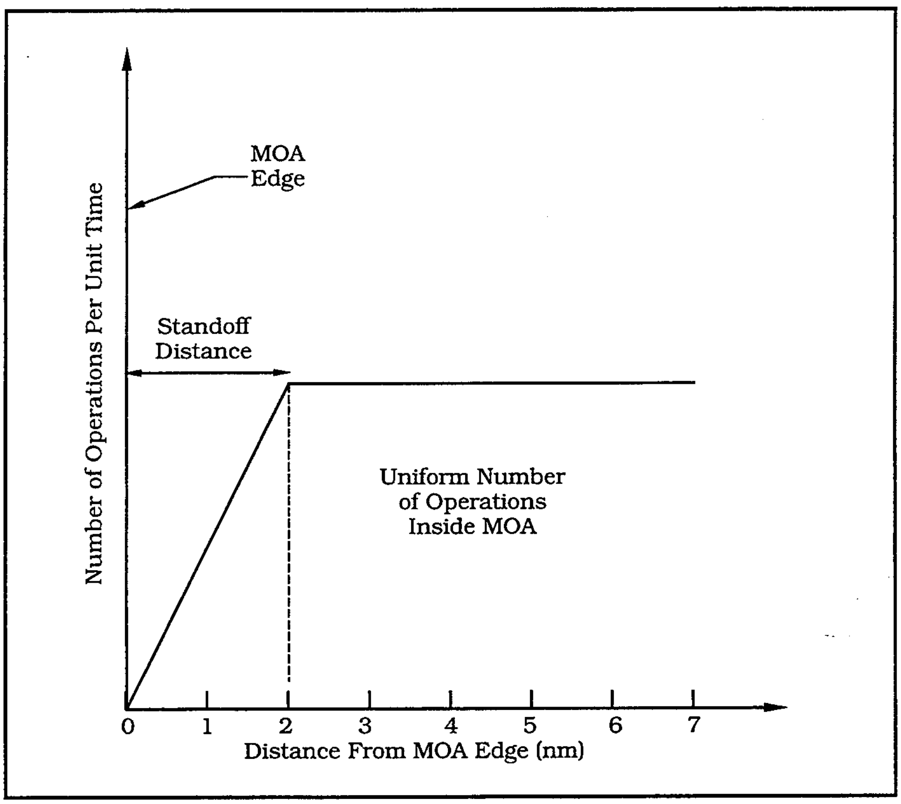


Figure 1-5. MOA Edge Model.

1.2.4 Avoidance Area Model

When a MOA/Range and an avoidance area intersect, MRNMAP sets the MOA floor equal to the avoidance area ceiling and recalculates the effective altitude using the new value for the MOA floor. The effective altitude calculations follow the same rules as before, with the exception that the MOA floor is now the avoidance area ceiling. If the altitude profile is below the avoidance area ceiling, the effective altitude is equal to the avoidance area ceiling. Operations no longer fly through the avoidance area, but rather fly above it at an altitude equal to the avoidance area ceiling.

1.2.5 Track Models

Distributed operations on a track are modeled as a Gaussian distribution of line sources. The standard deviation for the Gaussian distribution can be supplied directly by the user or calculated from the given route width, using the procedure of Reference 5. When the route width is specified the program calculates the standard deviation by multiplying the total (left + right) width by 0.17. If the resulting standard deviation is less than 1 nm the standard deviation is set equal to 1 nm.

In MRNMAP distributed operations are modeled as a single dominant line source when the user supplies a total route width less than 1 nm or a standard deviation less than 0.5 nm. When the operations are distributed, MRNMAP uses the same algorithms contained in ROUTEMAP. If the operations follow a single track, MRNMAP uses the algorithms identical to those found in NOISEMAP. Choosing a route width less than 1 nm or a standard deviation less than 0.5 nm effectively switches the noise models in MRNMAP.

Circular ground tracks or turns are modeled in MRNMAP as an even number of connecting line segments. The segments length is selected so that the subtended angle of a segment is no greater than 30 degrees. Finite-length approximations are made on all line segments using the same algorithms contained in NOISEMAP.

1.3 Scope

MRNMAP computes cumulative noise in military airspaces. The lowest permissible altitude that can be entered into the model is 50 feet AGL. It also does not model aircraft takeoffs and landings. When airbase operations are to be modeled, NOISEMAP must be used.

Because of the stochastic nature of airspace operations, MRNMAP does not account for detailed power and speed changes along a track. The user is expected to enter average operating conditions for the aircraft's power and speed. These average conditions are interpreted into an SEL-versus-distance relationship using OMEGA10 and NOISEFILE. The calculations are then carried through to develop average noise contours.

MRNMAP is also limited to subsonic operations. If sonic booms from supersonic operations are to be modeled, Boomap3,[6] CORBOOM,[7] or MOABOOM[8] must be used.

2.0 SURVEY OF AIRCRAFT OPERATION IN MOAs AND RANGES

The noise models in MRNMAP are based on tracking data that was collected from three military installations. The purpose for collecting the tracking data was to study and quantify the operations of military aircraft in MOAs and Ranges during training and combat exercises. This chapter reviews the analysis performed on the data. Section 2.1 describes the type of data collected from each of the installations. Section 2.2 shows the average altitude and speed ranges flown by military aircraft. Section 2.3 describes how the tracking data was used to develop a model to characterize the decreasing number of operations near a MOA's edge. Section 2.4 uses the tracking data to describe the training activity on a conventional range.

2.1 Tracking Data

More than 10,000 hours of tracking data were collected from the Nellis Air Force Range and the Volk Field Air National Guard Hardwood Range Air Combat Maneuver Instrumentation (ACMI) system. The ACMI system consists of a set of ground tracking stations and a transponder pod attached to several of the aircraft participating in the exercise. Each transponder pod contains its own internal navigation system. It sends flight data, which includes the aircraft coordinate position, velocity, altitude, angular rates, and air speed, to a base receiver every 100 to 200 milliseconds. These data are recorded and used to generate a video display for the pilots to observe and critique the mission as it took place. The data is recorded and stored on magnetic media and was provided by the various commands for this study.

At the Nellis Range, the ACMI system has coverage over most of the range down to the surface. Two years of tracking data were collected from the Nellis AFB Range Center. At Volk Field, ACMI is used to track military aircraft on Volk East and West MOAs, and in the Hardwood Range (R-6904A and B). The ANG at Volk Field supplied 90 days of ACMI data for this study.

Radar data is another source of tracking data. Ninety days of radar data was collected from the Inyokern Municipal Airport radar site located near China Lake, California. The radar antenna is approximately 7.5 nautical miles from a target area called the Baker Range. In the vicinity of this radar installation the area is extremely flat; thus the radar can track the aircraft down to the surface. Contained

in the radar data is the aircraft position, time, and identification code. This data is transmitted every 3 to 5 seconds. Information not available from radar data are the aircraft performance parameters such as the aircraft velocity and acceleration components, angular rate, and air speed.

The main advantage of ACMI data is the wealth of information transmitted to the ground base receiver on the aircraft performance. However, not all of the aircraft participating in an exercise carry a transponder pod. In fact, based on historical data, only 20 to 30 percent of the aircraft that use the Nellis and Hardwood Ranges carry a pod. At the China Lake site, the use of radar data made it possible to obtain tracking information on all the aircraft on the range. The disadvantage of radar data is that only the aircraft type and position are known.

2.2 Aircraft Altitude and Speed Profiles

Almost all of the training exercises conducted in MOAs and Ranges are conducted with a specific mission objective. Since the mission objective defines the aircraft function and purpose in the exercise, it is reasonable to assume that the mission objective is an important factor in determining how the aircrew uses speed, power, and altitude to carry out a given exercise.

In this section the ACMI data collected from Nellis AFB is used to study altitude and speed profiles based on aircraft and mission type. Exclusive to the Nellis ACMI system, the Range Control Group tracks the aircraft mission objective during an exercise. Table 2-1 presents the data collected from Nellis AFB. The data was obtained by reading the historical records archived on magnetic media. A total of seven exercises were obtained. A Nellis exercise lasts between five and six weeks and typically involves about 80 fixed-wing aircraft.

Consider Red Flag 92-2, which was conducted between 4 January and 15 February 1992. During this exercise there were a total of 24 flying days that involved military aircraft carrying transponder pods. A flying day will usually have a morning and afternoon session, each lasting approximately two hours. As shown in the table, Red Flag 92-2 had 1,653 aircraft carrying transponder pods. This equates to a total of 3,138 hours of tracking data.

Table 2-1

Overview of RFMDS Tracking Data

Exercise Name	Exercise Date	No. of Flying Days	Total Number of Missions Flown		Total Number of Hours Flown	
			No. of Missions	% Usable Data	No. of Hours	% Usable Data
Red Flag 92-2	4 Jan – 15 Feb 92	24	1,653	78%	3,138	98%
Green Flag 92-3	29 Feb – 15 Feb 92	18	1,661	97%	*	0%
Red Flag 93-1	10 Oct – 21 Nov 92	13	618	61%	481	99%
ME	1 Dec – 19 Dec 92	8	387	0%	262	0%
Red Flag 93-2	2 Jan – 20 Feb 93	20	1,072	95%	1,035	99%
Green Flag 93-3	6 Mar – 17 Apr 93	30	1,473	90%	2,361	99%
Red Flag 93-4	26 Jun – 7 Aug 93	25	1,655	97%	1,249	99%

* Data field showing the system time is not reliable.

The ACMI data provided by the Nellis Range Control Group was screened for errors then compressed for future data processing. When an error was detected the data was eliminated from the sample. The most frequent source of data error was caused by the system clock not recording the time correctly. Another common error was due to incomplete data fields and corrupt data. Percent usable data, as listed in the table, shows the quantity of data that passed all of the screening tests.

The ACMI data contains many different types of aircraft performing a range of mission objectives. Table 2-2 summarizes the aircraft types and the missions flown. The column headings in the first row lists the mission names and the first column lists the aircraft types. The symbol notation is used to cross-reference the name of the exercise to the aircraft and mission type. As an example, the B-52 performed two missions: Interdiction and Offensive Counter Air. The interdiction mission was flown in five of the seven exercises and the Offensive Counter Air mission was flown in two of the exercises.

The computer programs that analyzed the ACMI data step through each sortie record one at a time. The programs organize the data by the aircraft and mission type. That is, the program tracks a specific aircraft and mission type, the time the aircraft spends at different altitudes, and its speeds. The results from this analysis are shown in Appendix A and B.

Table 2-2

Aircraft and Mission Type Contained in RFMDS Data

Military Aircraft	**Missions**											
	Battle Field Air Interdiction (BAI)	**Close Air Support (CAS)**	**Defensive Counter Air (DCA)**	**Escort (ESC)**	**Electronic Warfare (EW)**	**Forward Air Control (FAC)**	**Interdiction (INT)**	**Offensive Counter Air (OCA)**	**Suppression of Enemy Air Defense (SEA)**	**Tactical Air Drop (TADP)**	**Wild Weasel (WW)**	**Other (OTR)**
A-10	✳ ○	○ ☆ ✳		✳		☆ ✳						
B-52							○ ✳ ☆ □ △	☆ □				
C-130										○ ☆ □ ◇		
EA-6B					☆				○ ✳			
F-14			○ ☆									
F-15				○ ☆ △ ◇			○ ✳ ☆ □ ◇	○ ✳ ☆ □ ◇				○
F-16		☆	○ ✳ ☆ △ □ ◇	△ ☆			○ ✳ ☆ △ □ ◇	○ ☆ □ △ ◇				○ ◇
F-18			○ ☆ △ ◇								☆	
F-111/EF-111 (ECM)					☆		○ △ ☆ ✳	○ △ ☆				
Tornado				□			○ □ ◇	○ □ ◇				○

Symbol	Mission Names	Symbol	Mission Names
○	Red Flag 92-2	◇	Red Flag 93-2
△	Green Flag 92-3	☆	Green Flag 93-3
□	Red Flag 93-1	✳	Red Flag 93-4

The final outcome of this study is histograms of altitude and speed for a given aircraft flying a given mission. This information is then processed to derive the equivalent acoustical altitude (EAA) and the time-weighted average airspeed. The EAA was described in Section 1.2.2. The weighted average airspeed is a summing process that normalizes the airspeed to the total mission time.

Table 2-3 shows the results of these calculations. Each aircraft and mission category is reported separately. The column labeled "Air Speed Less Than 10 Percent Of Time" shows the speed in knots which the aircraft fly less than 10 percent of the time. For example, the A-10 on a Close Air Support mission will fly less than 240 knots 10 percent of the time. Similarly, the same aircraft will fly an average of 318 knots and spend 90 percent of the time below 460 knots. The "Average Time On Range" is the time in minutes the aircraft are on the Nellis Range. The "Number Of Samples" shows the number of aircraft, with tracking data, that entered into the calculations.

More than half of the operations on the Nellis Range have an equivalent acoustical altitude between 500 and 1,000 feet AGL, with a majority of the operations below 1,500 feet AGL, as shown in Table 2-3. Similar observations have been made during the data collection process for Environmental Assessments and Environmental Impact Statements. It is frequently observed that the data provided by pilots yield a range of EAAs that fall within the same range as those measured using ACMI data.

Finally, it shall be noted that the altitude and speed ranges appearing in Table 2-3 may be used in calculating the noise environment for MOAs and Ranges when details on the operations are unknown. These values should, of course, be used only when specific local information is not available.

2.3 Operations Near A MOA Edge

In this section, ACMI data from the Nellis Range is used to demonstrate that the number of operations decrease at a linear rate near a MOA edge. From this relationship a noise model is developed and used in MRNMAP to taper the noise near the edges of MOAs and Ranges. This section begins with a discussion on the training activity at Nellis, followed by an analysis of the spatial distribution of operations on the range and near its borders.

Table 2-3

Altitude and Speed Summary of RFMDS Data

Aircraft/ Mission	Equivalent Acoustical Altitude (Ft AGL)	Air Speed Less Than 10% of Time (Kts)	Air Speed Average (Kts)	Air Speed Less Than 90% of Time (Kts)	Average Time on Range (Min.)	No. of Samples
A-10 / CAS	943	240	318	460	51	220
A-10 / ESC	1,076	230	284	330	53	14
A-10 / FAC	681	240	291	340	63	33
A-10 / BAI	648	250	327	450	68	25
B-52 / INT	604	340	444	550	46	59
B-52 / OCA	552	340	438	540	46	15
C-130 / TADP	805	310	443	550	38	18
EA-6B, E-6B / EW	651	220	371	500	55	16
EA-6B / SEAD	799	360	459	550	33	11
F-14 / DCA	1,253	340	438	560	61	147
F-15 / ESC	1,328	400	505	600	49	353
F-15 / INT	979	370	484	580	44	177
F-15 / OCA	1,149	380	493	590	49	747
F-15 / OTR	2,385	400	460	530	37	7
F-16 / CAS	1,454	350	457	560	55	53
F-16 / DCA	1,794	370	472	590	50	1,236
F-16 / ESC	2,303	380	481	580	32	34
F-16 / INT	696	360	463	560	42	726
F-16 / OCA	854	370	471	570	43	255
F-16 / OTR	918	370	465	560	35	21
F-18 / DCA	1,039	370	473	580	40	153
F-18 / WW	812	370	473	580	42	28
F-111 / EW	1,120	370	477	580	55	25
F-111 / INT	610	360	458	560	48	227
F-111 / OCA	628	370	475	580	39	98
Tornado / ESC	2,401	370	474	590	44	24
Tornado / INT	595	360	461	540	38	206
Tornado / OCA	495	350	460	550	38	293
Tornado / OTR	995	380	452	510	39	12

The Nellis Range complex consists of Restricted Areas, MOAs, and bombing ranges (see Reference 9 for definitions of these airspace components). The range covers over 13,000 square miles. A sketch of the major airspace boundaries is shown in Figure 2-1. Most of the aircraft that use the range are staged out of Nellis AFB. During a major exercise, fighter and bomber squadrons, from military bases throughout the country, assemble at Nellis AFB to participate in the exercise. The purpose of an exercise is to practice, in as realistic a setting as possible, air-to-air and air-to-ground combat. An exercise lasts approximately five to six weeks. On most days, during a major exercise there are between one and two practice sessions held on the range. A typical session has two teams consisting of 20 to 40 aircraft. One team represents the aggressor and the other the defender. A session begins with the aircraft entering the range through the Sally Corridor. The aircraft head north up the Sally Corridor, proceed past Hico, Rachel, and into R-4807. Air-to-air and air-to-ground combat are done in R-4807. When the exercise is complete the aircraft return to Nellis AFB either through R-4808 or the Sally Corridor. Pictured in Figure 2-2 are the ground tracks that represent one two-hour session.

The first step in analyzing the distribution of aircraft on the range consists of defining a grid of gates, spaced 10 miles apart. A gate was used to develop a two-dimensional representation of the aircraft's vertical and horizontal distribution. The gates were aligned west to east and south to north, as in Figure 2-3. A computer program was written to read the tracking data for each sortie and determine if the aircraft intersected one of the 17 gates drawn in Figure 2-3. When an aircraft passed through a gate, the computer program recorded the point where the plane of the gate intersected the aircraft flight track. This point was defined in terms of the gate's horizontal and vertical axes. A second computer program read a file containing the intersecting points and drew histograms that depicted the population of aircraft along the horizontal and vertical axes of the gates.

Results of these calculations are shown in Figures 2-4 and 2-5. The distributions shown in these figures represent over 8,000 hours of aircraft operations on the Nellis Range from a two-year period. In Figure 2-4 the pronounced peak centered at $X = 60$ miles is attributed to the operations along the Sally Corridor. From $Y=0$ through $Y=30$ miles, the operations along Sally Corridor decrease and also shift to the west of Sally Corridor. This westward shift in the distributions is due to the movement of aircraft between the Desert MOA and R-4807.

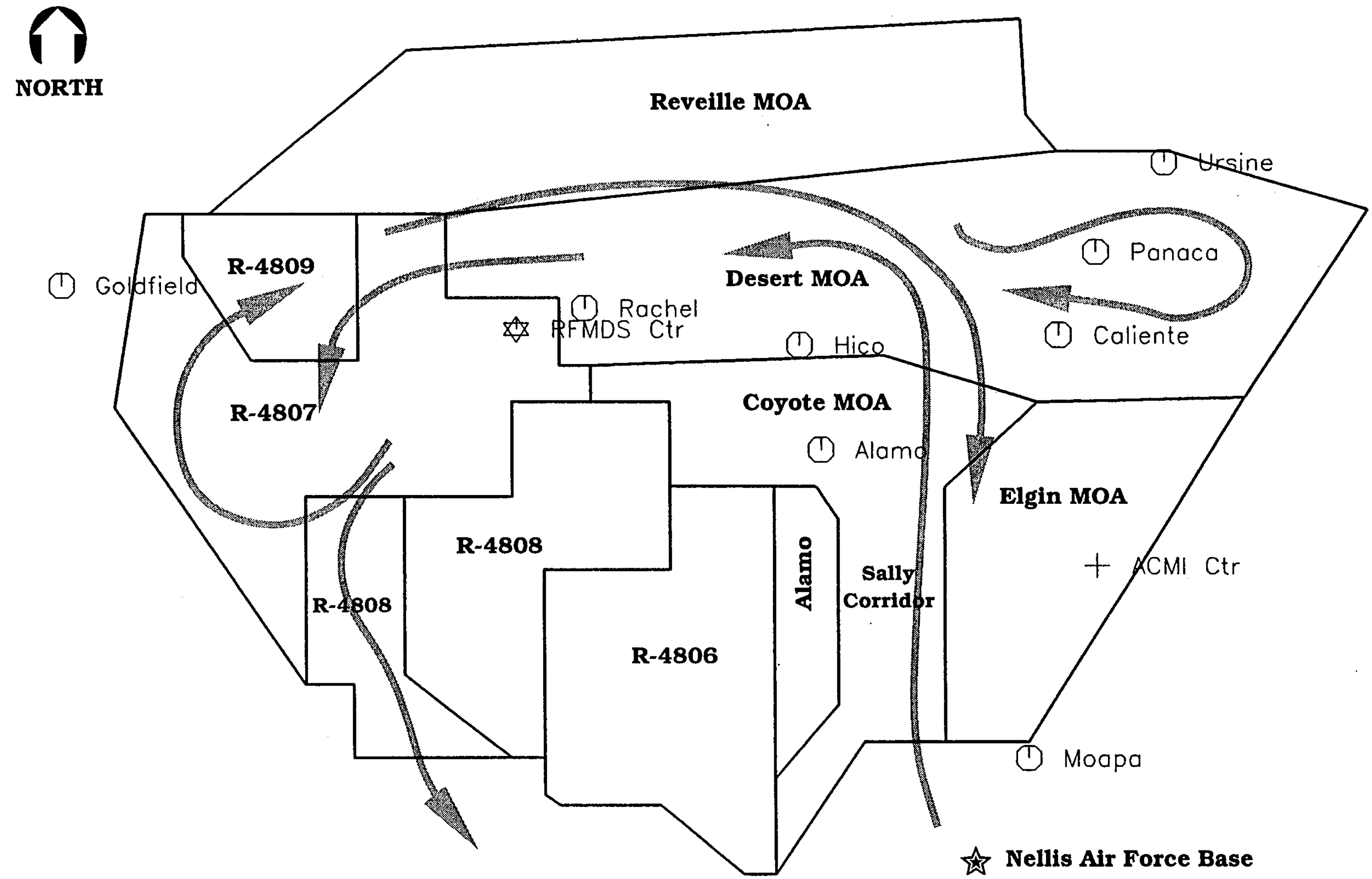


Figure 2-1. Nellis Range Complex.

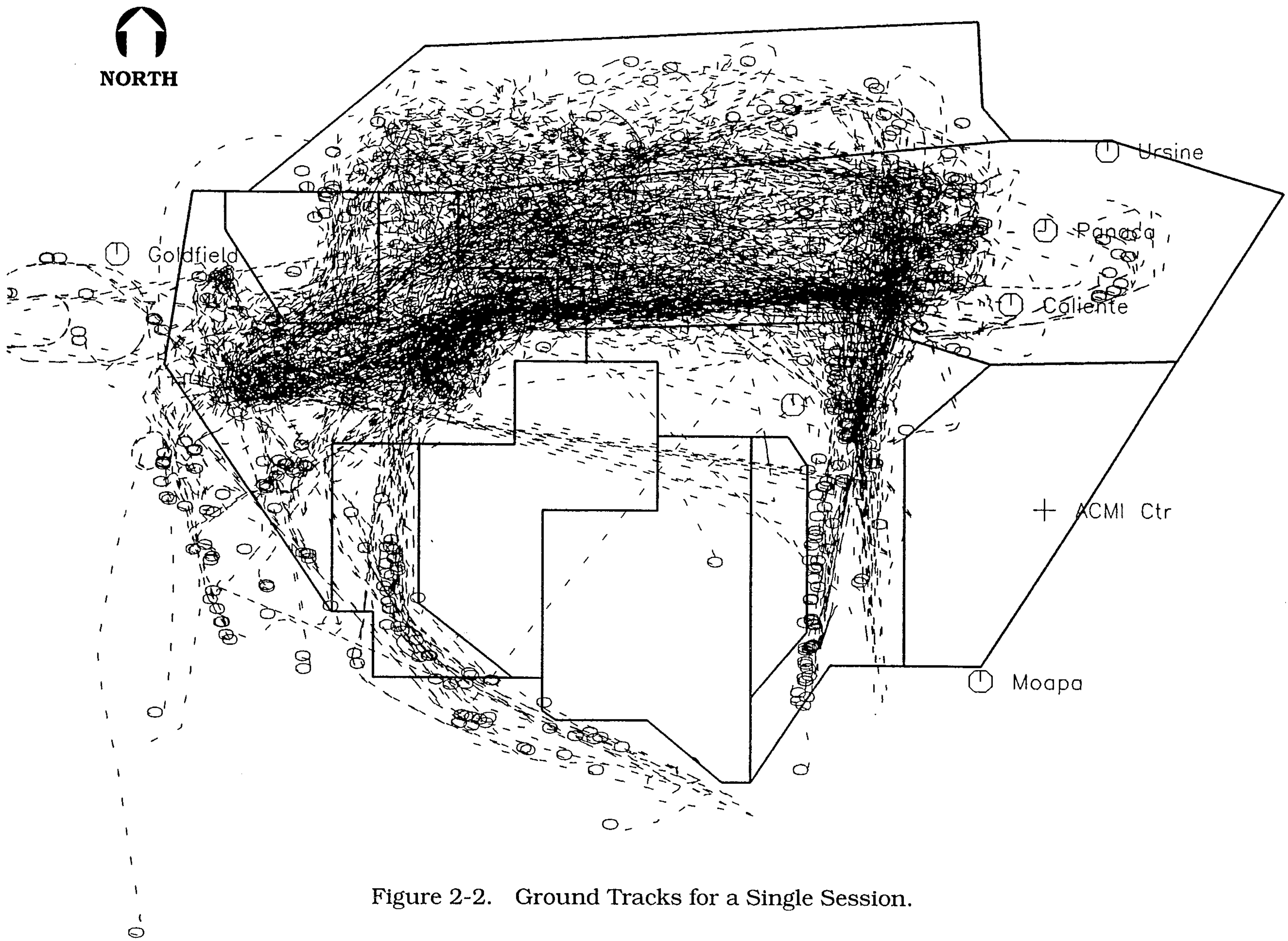


Figure 2-2. Ground Tracks for a Single Session.

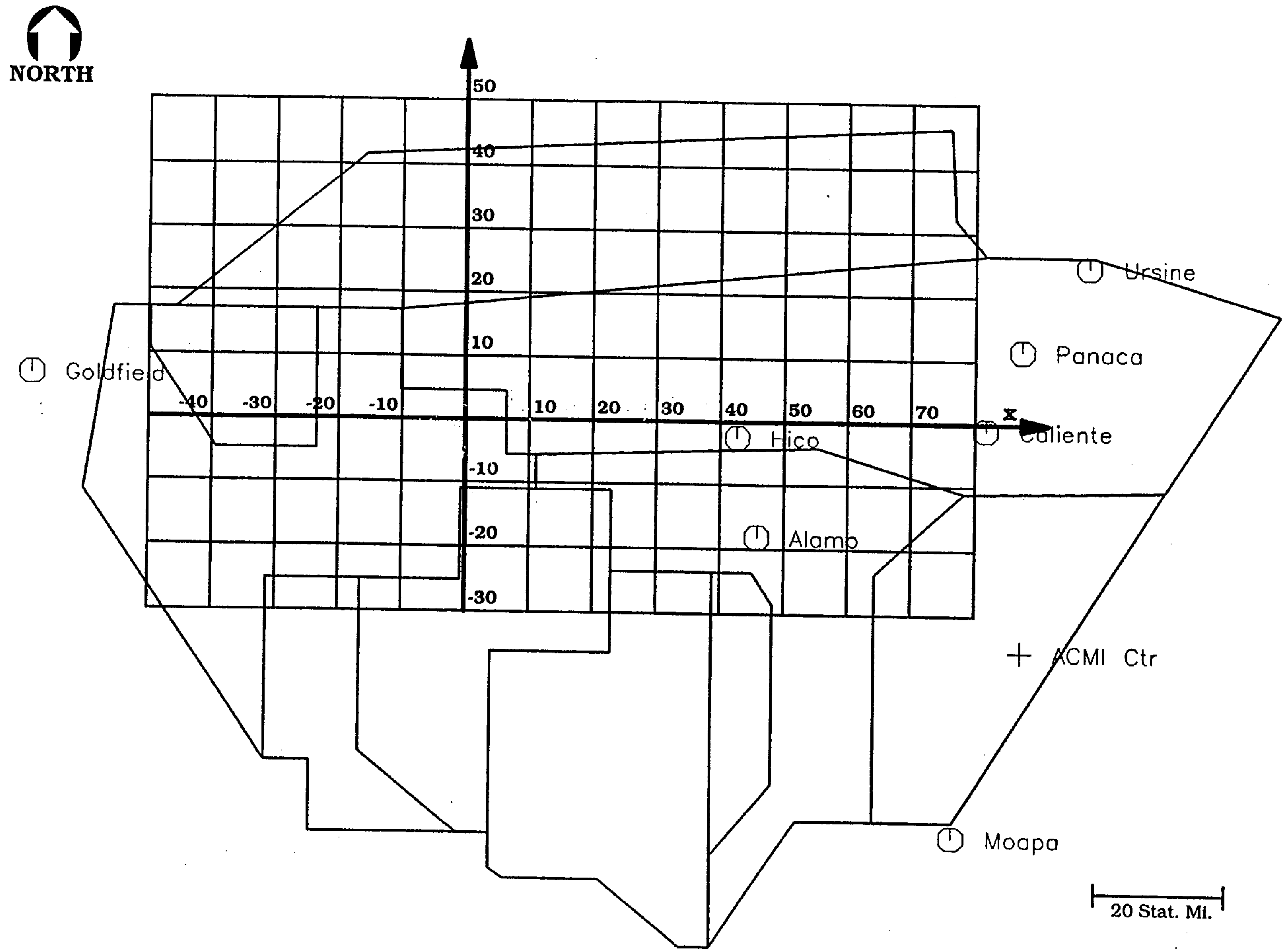


Figure 2-3. Locations of Gates.

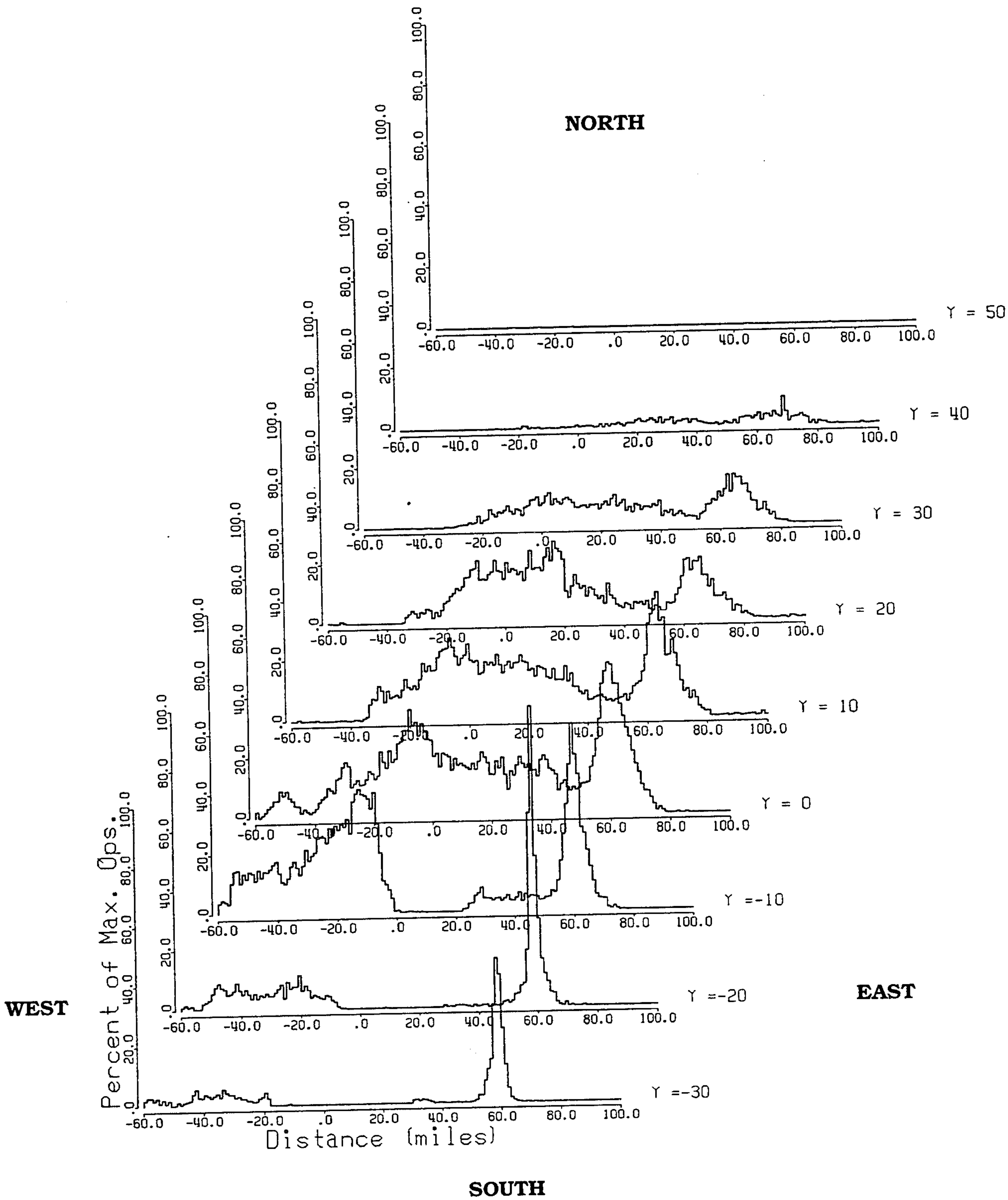


Figure 2-4. Gates 1 Through 9, Running West to East.

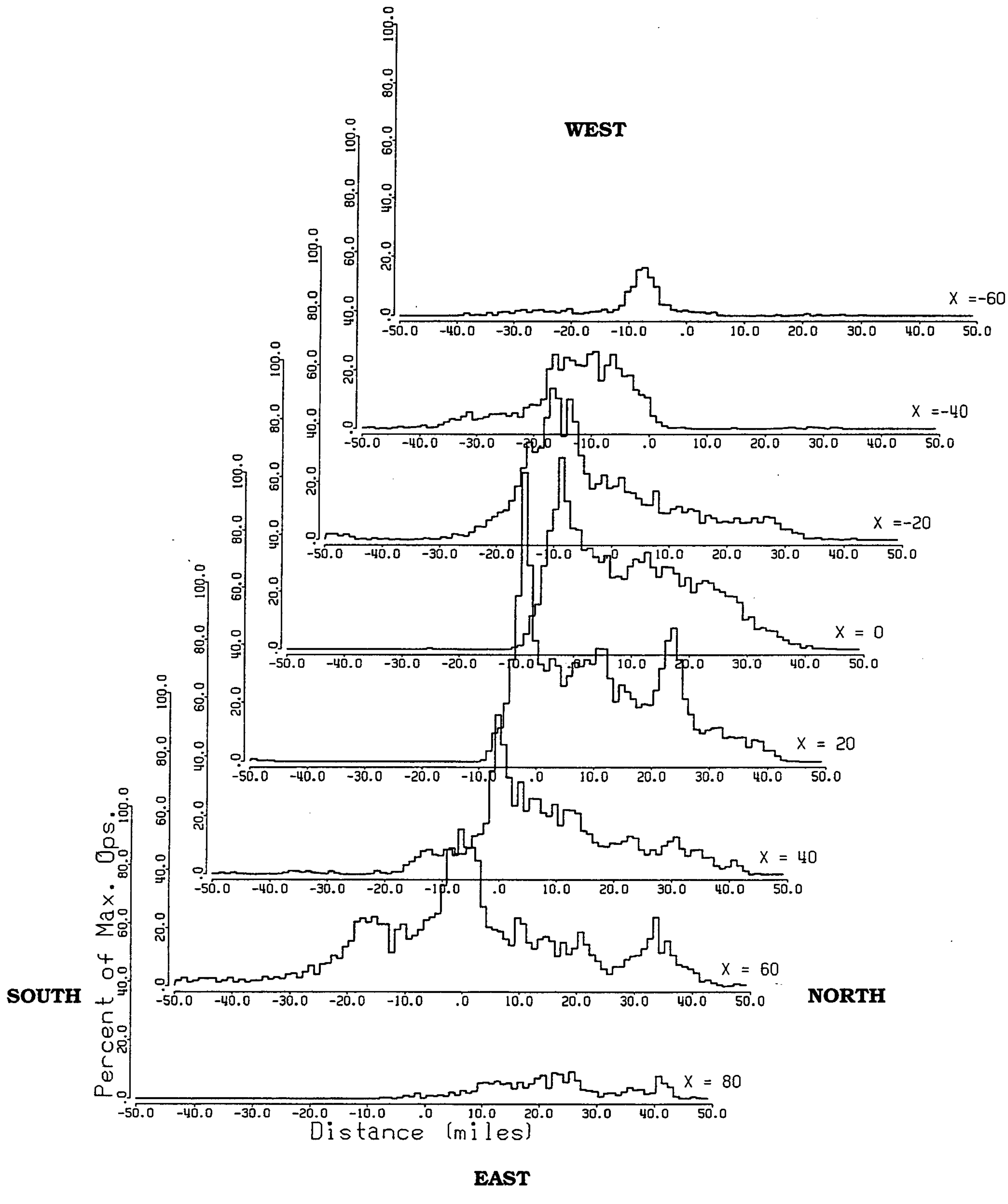


Figure 2-5. Gates 10 Through 17, Running South to North.

Near the edges of a MOA, it is expected that the operations will drop off to a zero value. The rate at which operations decrease can be modeled as a straight-line fit, as shown in Figure 2-6. The distance from the MOA edge where the transition from a "uniform" distributed level of operations to a decreasing level of operations is called, in this document, the standoff distance (see Figure 1-5). The standoff distance will vary depending on the MOA size, shape, and purpose. At the Nellis Range, a uniform distribution of operations is never truly attained because the range is over 13,000 square miles in area. Thus the standoff distance cannot be meaningfully measured using the RFMDS data from the Nellis Range.

As an alternate approach to determining the standoff distance consider the following formulation for relating operating speed and distance:

$$ng = \omega^2 r \tag{2-1}$$

$$V_\theta = \omega r \tag{2-2}$$

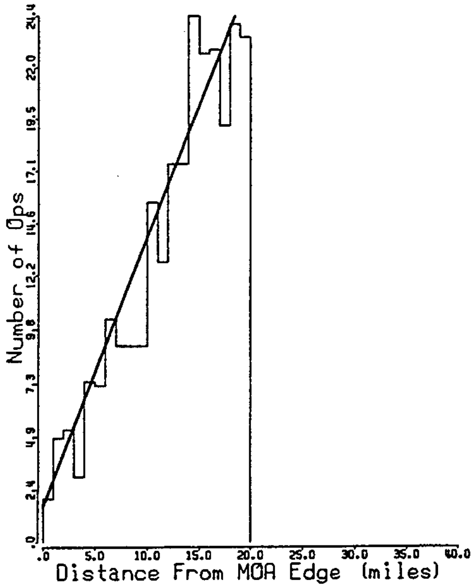
where n is an integer, g is the acceleration due to gravity, ω is the angular rate, r is the turn radius, and V_θ is the speed in the theta direction. Eliminating ω from both equations gives

$$r = \frac{V_\theta^2}{ng} \tag{2-3}$$

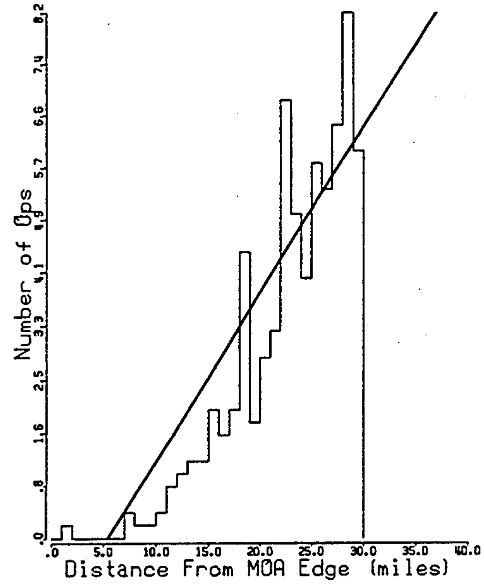
The acceleration due to gravity is 68,617 nm/hr^2 and the normal acceleration for military aircraft is typically between 1 and 5 g's. Substituting for V_θ the average air speeds appearing in Table 2-3, it is found that the turn radius is between 1 and 5 nautical miles. The turn radius is the minimum required distance to avoid overflying the edges of a MOA and in this report is taken as the standoff distance when aircraft operations are evenly distributed within the confines of the MOA. MRNMAP uses for the standoff distance a value of 0, 1, 2, and 5 nautical miles.

2.4 Operations On A Range

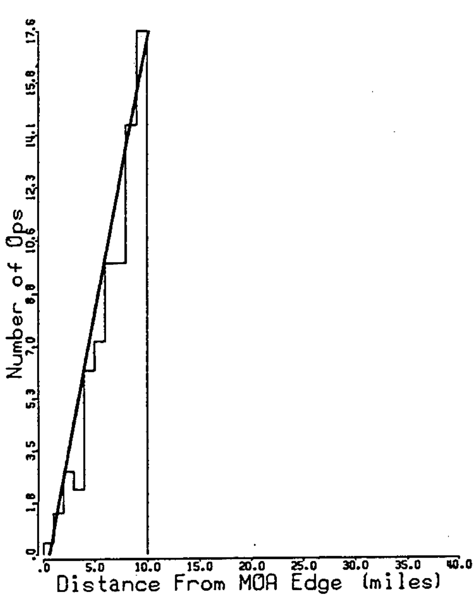
The Department of Defense employs several types of air-to-surface ranges designed to support different levels or types of training. The differences between conventional and tactical ranges lies mainly in the purpose of the overall training objective.



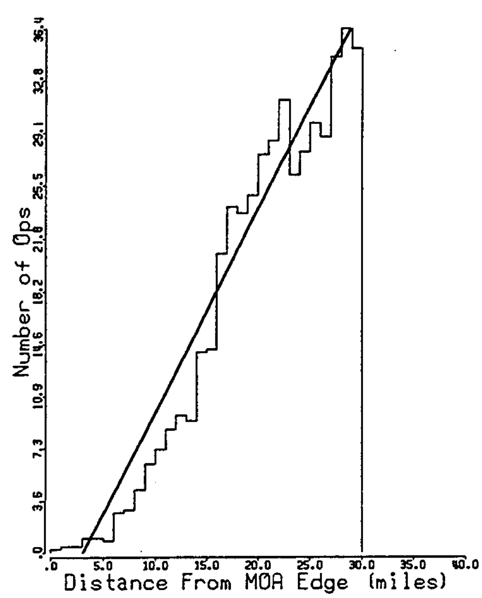
(a) Gate 6, Y = 20, East Edge.



(b) Gate 7, Y = 30, West Edge.



(c) Gate 11, X = 60, North Edge.



(d) Gate 14, X = 0, North Edge.

Figure 2-6. Samples of Straight-Line-Fit Near MOA and Range Boundaries.

The training objective in utilizing a conventional range is to familiarize a crewmember new to an aircraft or weapon system with the proper procedures for employing different weapons. Thus a conventional range is designed to provide a highly structured training environment for aircrews. To minimize the difficulty in locating a target, most targets are made highly visible from the air by plowing the soil around the targets, painting the targets, creating clearly defined run-in lines for guidance, and lighting the target. There are other visual cues to help the aircrew remain oriented, such as range towers, well-maintained roads, maintenance and administration buildings, and the known proximity of the target to other military or civilian facilities. All of these recognition aids are used to ease the difficulty of acquiring a target in order that the new crewmember might concentrate on mastering the aircraft, its weapon system, and delivery techniques.

Tactical target complexes, on the other hand, are used to challenge combat-ready pilots and to further hone their skills at not only weapon delivery, but also in visually differentiating a target from its background. Tactical ranges are further designed to permit greater freedom to the aircrew in terms of mission planning, tactics, and threat reduction. Due to the fact that targets are dispersed over a large area and are more difficult to locate, it presents aircrews with more challenging mission. Targets are not placed at the center of plowed circles, nor are there run-in lines to guide the pilot to the target. In fact, the purpose of the tactical range is to present a realistic target environment for realistic training. Instead of bomb circle targets, aircrews may encounter convoys, tanks, airfields, dispersed troop formations, industrial areas, and other targets they could or would expect to attack in combat. There are few man-made visual clues to orient them to the targets. Rather, they must rely more on accurate navigation, on-board computers systems, map/photo interpretation, geographic landmarks, and target identification. Flight patterns and attack headings are more varied and are usually limited by land and airspace boundaries, location of manned sites, terrain features, and target characteristics.

On conventional ranges the major variable in predicting the noise environment is the spatial distribution of run-in tracks. Current environmental assessments often assume a single predominant track. As illustrated in Figure 2-7, military aircraft training at the Hardwood range follows one of several common tracks. Each individual ground track is dispersed about a central track.

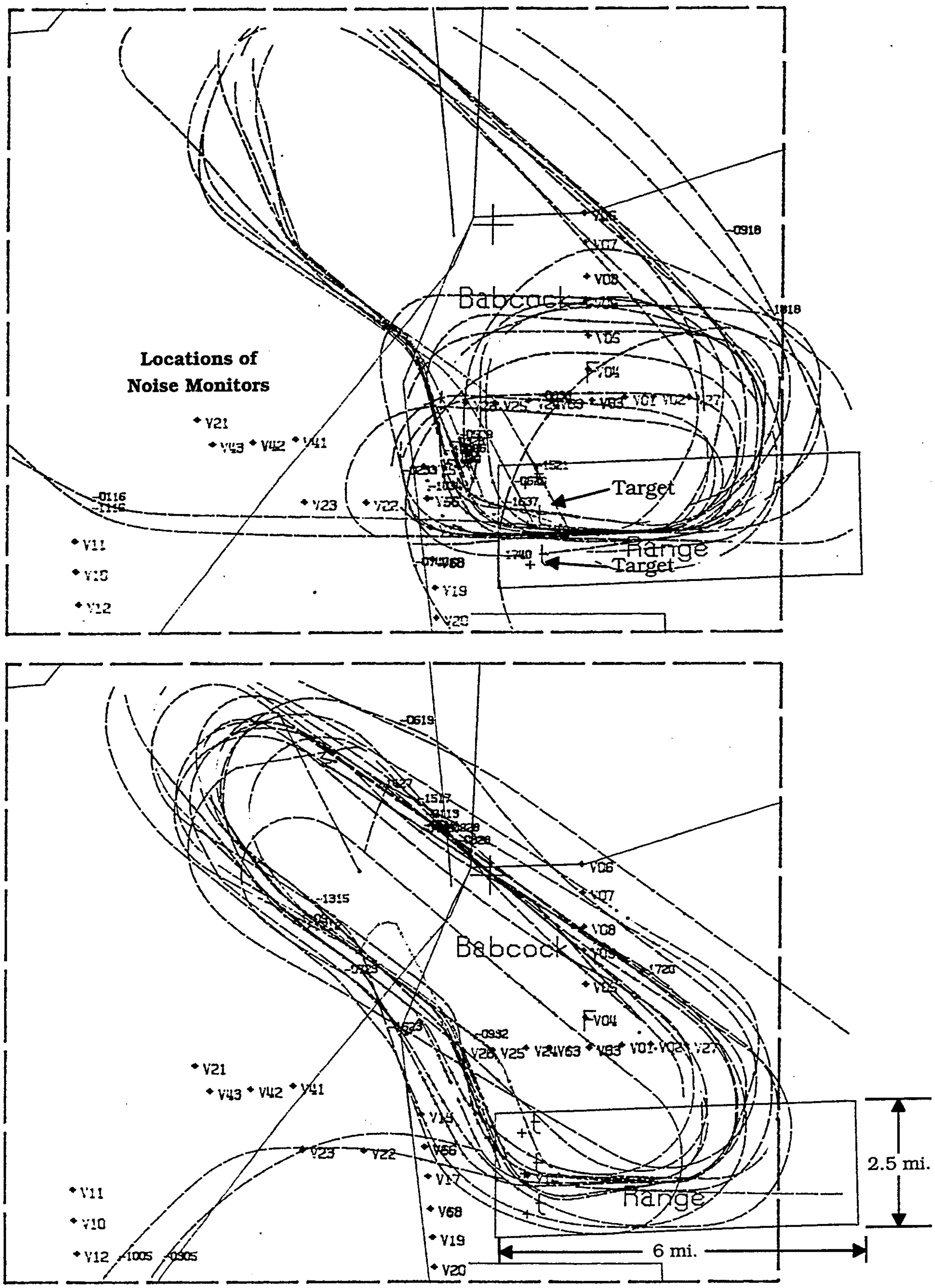
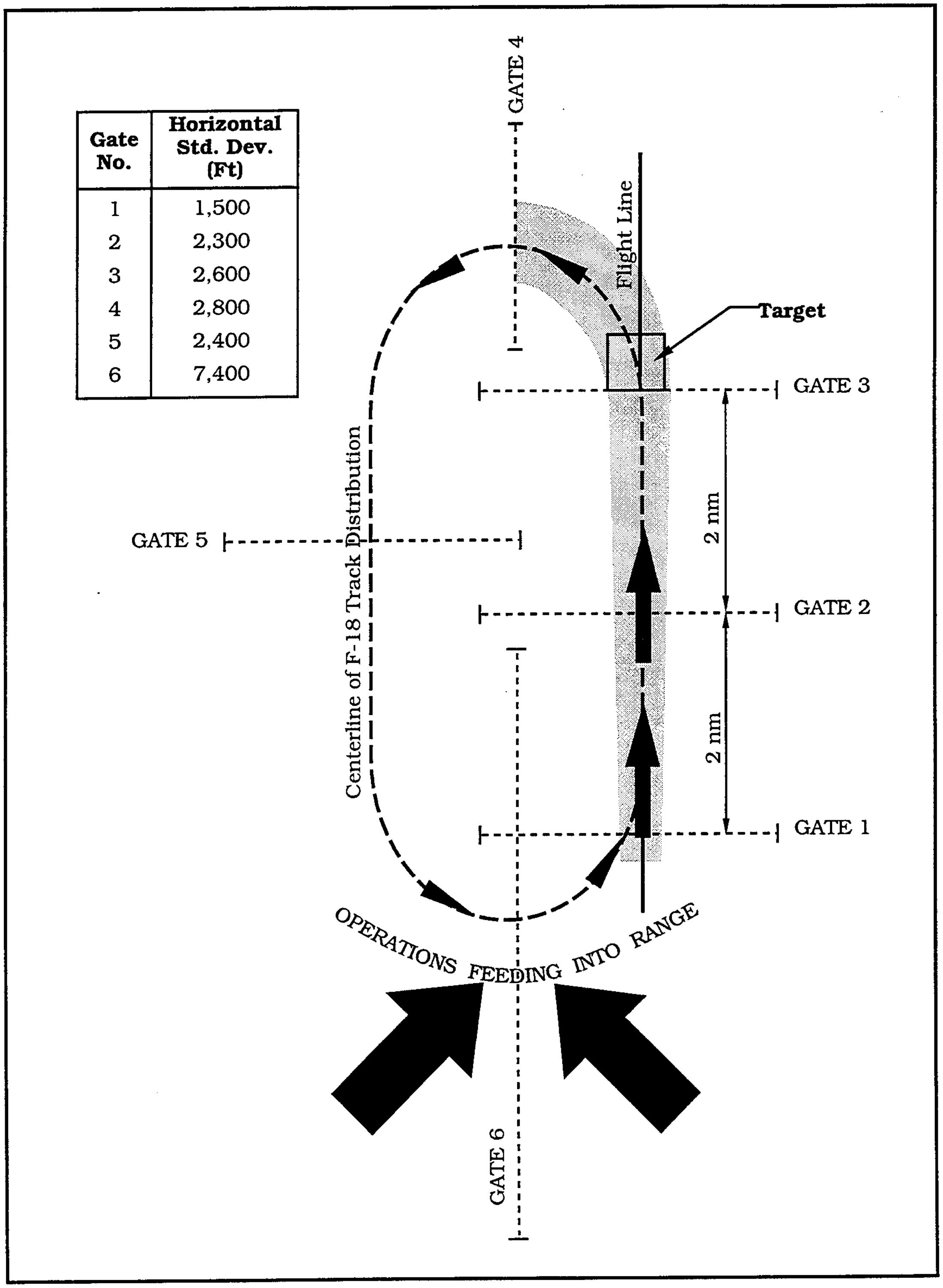


Figure 2-7. Flight Tracks on Hardwood Range.

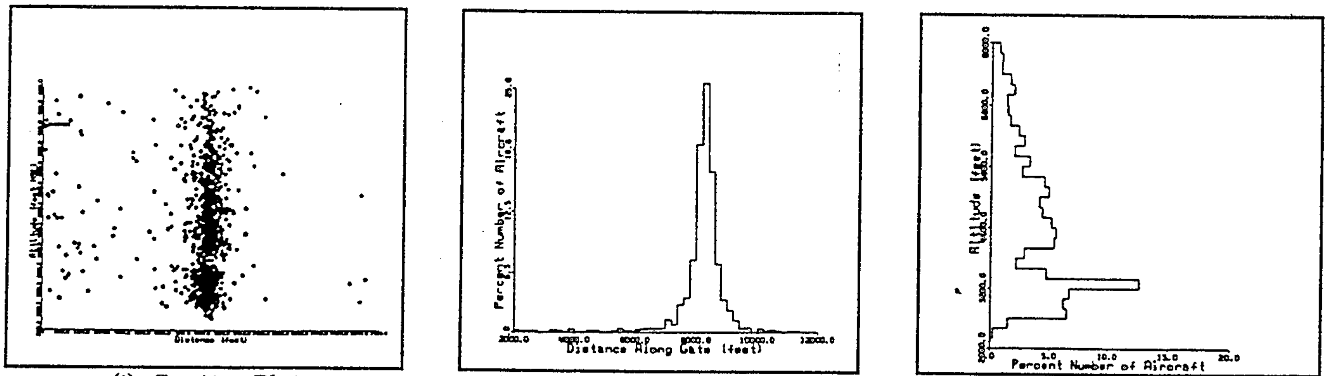
Similar observations were made at the Baker Range, where 90 days of radar data were collected. F-18s made extensive use of the range during the 90-day monitoring period. To determine the vertical and horizontal distribution of the aircraft, a system of gates was used to correlate the data. The operations followed a pattern as illustrated in Figure 2-8. In this figure six gates are located along the main track. The standard deviation at Gate 1 is found to have the smallest value. Gate 1 is located 4 nm prior to the target. At this location most of the operations in the horizontal direction are within 1,000 feet of the flight line, as may be seen in Figure 2-9. In Figure 2-9(iii), the altitude distribution is plotted in feet MSL. The ground elevation at Baker Range is approximately 2,000 feet MSL. The F-18s approach the target at an altitude between 500 and 1,000 feet AGL but are seen to rapidly ascend to a wider range of altitudes after leaving the target.

From the tracking data, it was discovered that the standard deviation about the central tracks varied between 1,500 and 3,000 feet for all aircraft types. The highest degree of dispersion was observed to occur when the central track turns 90 degrees or more. Furthermore, it was found that the aircrews always followed a single predominant track when approaching the target area: and the ground tracks became highly dispersed when the aircraft departed the target area and turned away from the line-of-flight. From this analysis, it is recommended that a value of 2,500 feet be used for the standard deviation on a bombing run pattern when specific local information is unavailable.



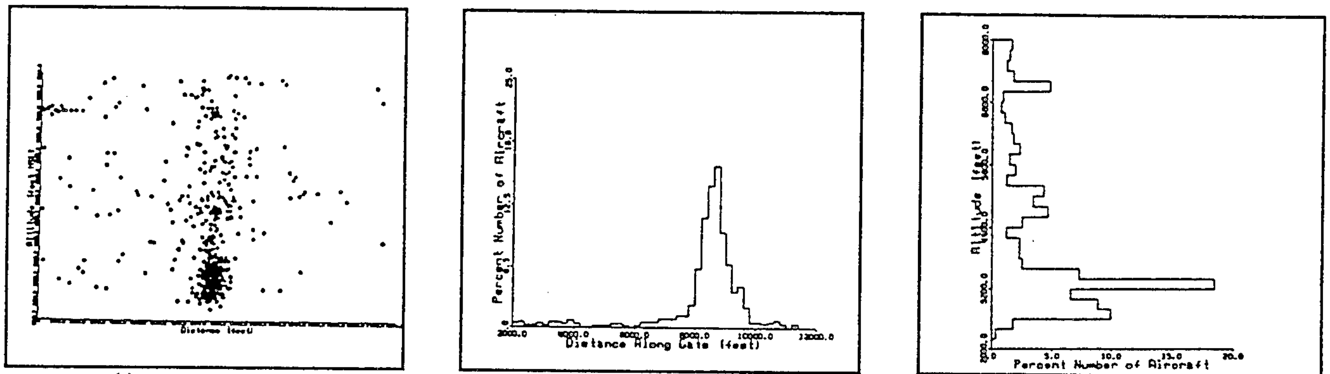
Gate No.	Horizontal Std. Dev. (Ft)
1	1,500
2	2,300
3	2,600
4	2,800
5	2,400
6	7,400

Figure 2-8. Schematic of F-18 Operations on Baker Range, NAWC China Lake.



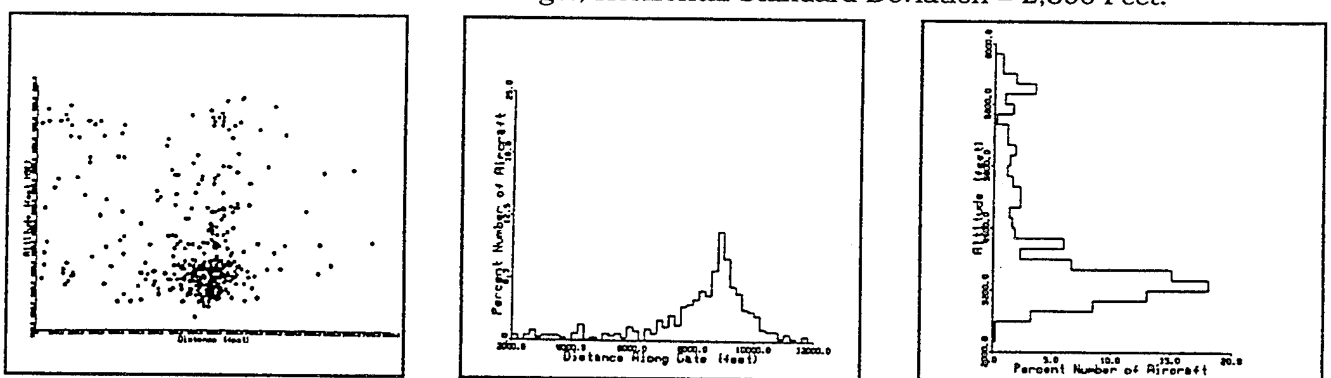
(i) Scatter Plot (ii) Horizontal Dispersion (iii) Vertical Dispersion

a. Gate 1: 4 nm Prior to Target, Horizontal Standard Deviation = 1,500 Feet.



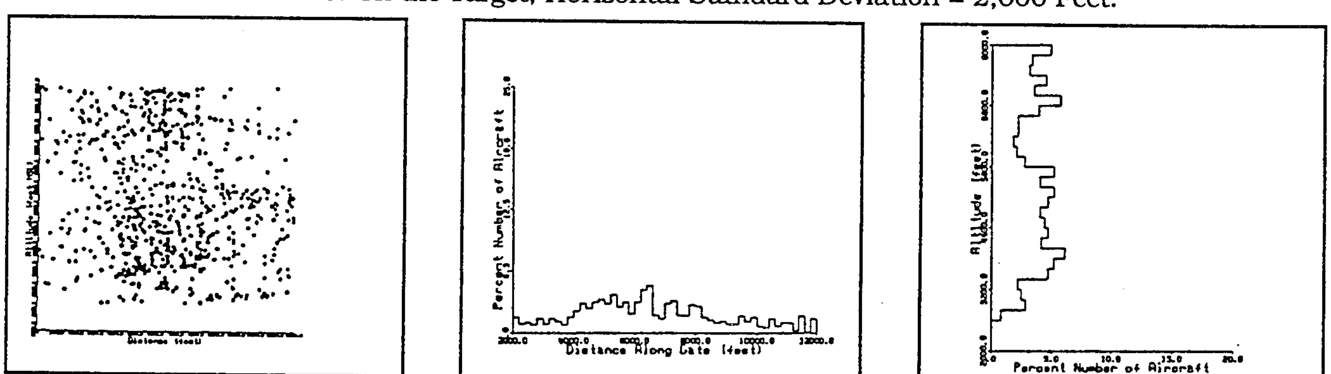
(i) Scatter Plot (ii) Horizontal Dispersion (iii) Vertical Dispersion

b. Gate 2: 2 nm Prior to Target, Horizontal Standard Deviation = 2,300 Feet.



(i) Scatter Plot (ii) Horizontal Dispersion (iii) Vertical Dispersion

c. Gate 3: At the Target, Horizontal Standard Deviation = 2,600 Feet.



(i) Scatter Plot (ii) Horizontal Dispersion (iii) Vertical Dispersion

d. Gate 4: 2 nm After Target, Horizontal Standard Deviation = 2,800 Feet.

Figure 2-9. F-18 Aircraft Dispersion on a Conventional Range.

3.0 USER'S GUIDE TO MRNMAP

MRNMAP reads an input file that contains the airspace specifications, mission profiles, and operation data. After processing this file, MRNMAP calculates the noise levels. This chapter describes the structure of the input file and the process by which noise levels are calculated. Section 3.1 describes the input keywords. Section 3.2 describes the organization of the input file. Section 3.3 gives instructions on running MRNMAP.

3.1 The Input File Keywords

MROPS creates an ASCII file (.INP) to transfer data to MRNMAP. The file is based upon a series of keywords which are used to specify all of the required data, as well as to control MRNMAP's computational procedures and reporting features. Although knowledge of this file is not necessary for the user to run any of the programs, it is possible to bypass MROPS and create and/or manipulate this file using a text editor.

MRNMAP has two kinds of keywords: keywords that are used to enter data into MRNMAP and keywords that control MRNMAP computational features. Eleven keywords are available to input data into MRNMAP. Following is a list of these keywords, each followed by a brief description of its purpose:

AREA SPECIFICATION – Specifies the MOA name, area, floor, and ceiling.

AVOIDANCE AREA – Specifies the name, center coordinates, radius, and ceiling of an Avoidance Area.

IMPORT SEL – Specifies the SEL versus distance values directly.

LOCATION – Specifies the latitude and longitude coordinates of the lower left and upper right corners of the grid, and the mean ground elevation.

MISSION – Specifies the name, aircraft type, power and speed setting, and the altitude profile for a mission.

MOA OPS – Specifies the numbers of aircraft sorties and the types of missions flown on a MOA or range.

MOA SPECIFICATION – Specifies the name, boundary points, floor, and ceiling of a MOA or range.

SETUP PARAMETER – Specifies the number of MOAs, Ranges, and Tracks, the size of the grid, the temperature, relative humidity, and number of days in a month, and the exceedance cutoff level.

SPECIFIC POINT – Specifies the name of a specific point and its location.

TRACK OPS – Specifies the numbers of aircraft sorties and the type of missions flown on an MTR or a Bombing Track.

TRACK SPECIFICATION – Specifies the name, turn points, route width, floor, and ceiling of an MTR or Bombing Track.

The second group of keywords controls the computational and reporting features of MRNMAP. The following is a list of these keywords, each followed by a brief description of its purpose:

CNEL – Sets the output noise metric to Community Noise Equivalent Level.

DIAGNOSTICS – Outputs an extensive number of internal diagnostic comments.

LDN – Sets the output noise metric to A-weighted day-night average sound level.

LDNMR – Sets the output noise metric to onset rate-adjusted monthly day-night average A-weighted sound level.

LEQ – Sets the output noise metric to Equivalent Sound Level.

LMAX – Sets the output noise metric to Maximum A-weighted Sound Level.

ONLY MOA – Limits noise level calculations to MOAs and ranges only.

ONLY TRACK – Limits noise level calculations to MTRs and Bombing Tracks only.

NO GRID – Limits MRNMAP output to a .TXT file only.

ASCII GRID – Outputs an ASCII grid file for inclusion into the Geographic Resources Analysis Support System (GRASS).

SEL – Sets the output noise metric to Sound Exposure Level.

SELR – Sets the output noise metric to onset rate-adjusted Sound Exposure Level.

TAPER 0 –Specifies that the aircraft fly in equal amounts at the center of the MOA and at the MOA edge.

TAPER 1 – Specifies a standoff distance of 1.0 nautical mile from the MOA edge. The standoff distance is defined as the distance from the MOA edge where aircraft begin their turn and operations begin to decrease.

TAPER 2 – Specifies a standoff distance of 2 nautical miles.

TAPER 5 – Specifies a standoff distance of 5 nautical miles.

DIAGNOSTICS – Outputs an extensive number of internal diagnostic comments.

ONLY MOA – Calculate noise levels on MOAs and Ranges only.

ONLY TRACK – Calculate noise levels on MTRs and Bombing Tracks only.

NO GRID – Report noise levels in the .TXT file only without producing the .GRD file.

There are three additional keywords available in the input file:

COMMENT or **REM** – Marks a comment line.

END – Marks the end of the file. Lines after this will not be processed by MRNMAP.

See Appendix C for the specific format of each of the keywords.

3.2 Organization

3.2.1 Data Entry Keywords

The organization of an input file is modeled after the steps followed when collecting operation data for an airspace analysis. The process of collecting operations data and entering the data into the input file is described in this section. Only the more experienced user should attempt editing the input file directly. For detail instructions on the file form and syntax, see Appendix C.

The first step in collecting operations data is locating the airspace on the aeronautical charts and determining its geographical coordinates. Entering airspace boundaries into MRNMAP is done using the SETUP PARAMETER, the MOA SPECIFICATION, and the TRACK SPECIFICATION keywords. The SETUP PARAMETER keyword appears first in the input file. This keyword specifies the grid

dimensions and the spacing between grid points. MOA SPECIFICATION and TRACK SPECIFICATION are the two keywords used to enter MOA, Range, and track coordinates. These two keywords are usually found near the beginning of the input file, following the SETUP PARAMETER keyword.

The second step in the data collection process is identifying the types of aircraft that use the airspace and their mission profiles. This information is entered into MRNMAP using the MISSION keyword. Under this keyword the user supplies the aircraft type, the power and speed setting, and the altitude profile. Often an airspace scenario will require several MISSION keywords, since one MISSION keyword is required for each aircraft type and MISSION profile.

The final step in collecting operations data is determining the number of missions flown in each airspace. Specifying the operations is done in MRNMAP using the MOA OPS and TRACK OPS keywords. Under the operation keywords appear the names of the airspace and missions. These names of airspace and mission are used when assigning the operations and may only be used after they have been defined under the MOA SPEC, TRACK SPEC, and MISSION keywords.

The END keyword follows the MOA OPS and TRACK OPS keywords. This keyword signals the end of the operation data and causes MRNMAP to stop reading the input file. Data that follows the END keyword is used by MROPS to draw the screen graphics and record editorial features. This data should be adjusted only via MROPS.

3.2.2 Control and Reporting Keywords

The keywords shown in Section 3.1.2, make it possible to control the calculations which MRNMAP performs for a given airspace scenario. To use these keywords, the keyword name is entered into the input file. No other data is required when using these keywords. The name of the keyword can be freely inserted anywhere in the file. When MROPS is used to create or manipulate the input file, the keyword names will appear near the end of the file, immediately before the END keyword.

The keywords are divided into three main groups: the first group specifies the noise metric, the second group specifies the model for tapering aircraft operations

near a MOA edge, and the third group is used for limiting the calculations performed, which can be helpful for locating errors in the input file. These keywords are organized as follows.

Noise Metrics – CNEL, LDN, LDNMR, LEQ, LMAX, SEL, and SELR.

MOA edge model – TAPER 0, TAPER 1, TAPER 2, and TAPER 5.

Program Control – DIAGNOSTICS, END, ONLY MOA, ONLY TRACK, and NO GRID.

The noise metric keywords specify which one of seven possible noise metrics MRNMAP is to use in its calculations. Only one metric keyword can be used at a time. When more than one metric is required, MRNMAP must be executed once for each noise metric. To specify a noise metric, simply insert the name of the keyword into the input file. If MROPS is used to create the input file, these options can be chosen from the **Run Options** dialog which is accessed through the **Options...** item in the **Run** menu. If none of these keyword names appear in the input file, MRNMAP will assume as the default an onset rate-adjusted day-night average A-weighted sound level (L_{dnmr}).

The MOA edge model keywords specify the procedure for tapering operations near a MOA edge. Section 1.2.3 describes the model used in MRNMAP and Section 2.3 provides the supporting experimental data. The distance from the MOA edge where the transition from a uniform distributed level of operations to a decreasing level of operations begins is called the standoff distance. Figure 1-5 shows a sketch of the MOA edge geometry. The standoff distance will vary depending on the MOA size, shape, and purpose. For example, small MOAs having a large number of operations will have a small standoff distance. The user has the choice of four standoff distance values varying between zero and five nautical miles. For most situations, the user will choose a standoff distance of 1 nm (TAPER 1) or 2 nm (TAPER 2). If no standoff distance is specified in the input file, MRNMAP will assume a distance of 0 nm.

The reporting control keywords are used to locate errors in the input file. Creating or manipulating the input file using a text editor is the most frequent cause of errors. When MRNMAP detects an error, one of the following two error messages will appear at the bottom of the FILENAME.TXT file:

*** READ ERROR FROM MR NMAP ***

or

*** ERROR IN SUBROUTINE blank ***

In the latter, blank is replaced with the name of the subroutine.

Read errors occur at the beginning of the program when MRNMAP is reading the input file and checking its syntax. The "ERROR IN SUBROUTINE ____" message occurs when an error, originating from the input file, is discovered during the calculations.

Following is a list of instructions on using the program control keywords to locate an error in the input file:

1. Add a DIAGNOSTIC keyword to the input file. This keyword will cause MRNMAP to report intermediate values.
2. Move the END keyword to other positions in the input file. This will cause MRNMAP to terminate early and output a text file that echoes the input data read thus far.
3. Add an ONLY MOA keyword. This will disable the track algorithms in RNMAP. If the program runs successfully, the error is located in the track section of the input file.
4. Add a ONLY TRACK keyword. This will disable the MOA algorithms in MRNMAP. If the program runs successfully, the error is located in the MOA section of the input file.
5. Add a NO GRID keyword. If the program runs successfully, the problem is located in the grid specifications.

3.2.3 Ordering of Keywords

Although keyword ordering is generally flexible, certain rules must be followed when creating or editing a MRNMAP input file without MROPS. These are as follows:

1. The SETUP PARAMETERS keyword must appear before any other *data specification* keyword.
2. The LOCATION keyword must appear directly after the SETUP PARAMETERS keyword.

3. An IMPORT SEL keyword must appear after the MISSION keyword that it references.

4. A MOA OPERATIONS keyword must appear after any MOA SPECIFICATION or MISSION keywords that it references.

5. A TRACK OPERATIONS keyword must appear after any TRACK SPECIFICATION or MISSION keywords that it references.

6. All data specification keywords, computational control keywords, and reporting feature keywords must appear before the END keyword.

Figure 3-1 is an example of an input file which follows the above rules and guidelines. Although not required, it is suggested that the MOA and TRACK SPECIFICATION keywords be placed directly after the LOCATION keyword. These should then be followed by the MISSION keywords, and then the MOA and TRACK OPERATIONS keywords.

3.3 Running MRNMAP

Once an input file is available for processing, MRNMAP can be run in one of three ways. The first is through the **MRNMAP** option in the **Run** menu of MROPS. Enter the name of the input file to be processed in the **File Name** field, or choose the input file from the list of files displayed, and click **OK**. A window will appear with the title "MRNMAPX - [Calculating noise levels for filename.inp]. This window will close when processing is complete.

The second is to run MRNMAP from Windows without the use of MROPS. To do this, choose the **Run** option from the Windows **File** menu. If the NOISE environment variable has been set up, simply type "mrnmapx" followed by the path and name of the input file in the **Command Line** field and click **OK**. If the NOISE environment variable has not been set up, prepend "mrnmapx" with its path. This method will also bring up the MRNMAPX window, which will close when the processing if the input file is complete.

The third way is to run MRNMAP from DOS. To get to a DOS prompt, either exit windows, or choose the MS-DOS prompt icon in the Main Windows program group. Change to the MRNMAP\DOSVER directory, and type "MRNMAP" followed by the name of the input file to be processed. Be sure to include the path of the input

```
                     SETUP PARAMETERS
                     1          0
SETUP                4895
PARAMETERS           1023952    11796792
                     1640417    12177374
                     59         70          30
                     65
                     LOCATION
                     032d30'00.0000"N    083d00'00.0000"W
                     033d30'00.0000"N    081d00'00.0000"W
                     0
                     MOA SPECIFICATION
                     BULLDOG A
                     8
                     1065578    11990057
AIRSPACE             1182032    12066868
SPECIFICATIONS       1217714    12054479
                     1289072    12059433
                     1311372    12015329
                     1328219    11919690
                     1107206    11848824
                     1065578    11990057
                     500        10000
                     MISSION
MISSION              F-16
SPECIFICATIONS       127        500         84
                     1
                     500        500         100
                     MOA OPS
                     1
OPERATIONS           BULLDOG A                          100
                     1
                     F-16       2500        0           1000        30
FEATURE              LDN
CONTROLS             TAPER 2
                     END
                     LABELS
                     1
                     BULLDOG A, 0
                     362852,3632071
                     USER INFO
                     ALPHA TESTER
                            BULLDOG AREA
                     BULLDOG A MOA
                     COORDINATES
                     BULLDOG A
                     033:01:01N,082:52:30W
                     033:14:01N,082:29:59W
                     033:12:01N,082:22:59W
                     033:13:01N,082:08:59W
                     033:05:46N,082:04:29W
                     032:50:01N,082:00:59W
                     032:37:51N,082:43:59W
                     500        ,10000
```

Figure 3-1. MRNMAP Input File SAMPLE1.INP.

file with the file name if it is not in the same directory. The output files (filename.INP and filename.GRD) will be created in the directory where the input file is located.

MRNMAP requires access to a file called "NOISE". When MRNMAP is unable to find the NOISE file, the message "ERROR READING NOISE DATA FILE" appears on the screen. If this error should occur, use an ASCII editor to add the line SET NOISE=C:\MRNMAP to the AUTOEXEC.BAT file and reboot the computer. This command tells MRNMAP where the NOISE file is located.

4.0 NOISE MODEL VALIDATION

This section reviews the tests that were performed to validate MRNMAP. Section 4.1 describes a measurement study that was conducted on the Baker Range located at the Naval Air Warfare Center China Lake, California. The purpose for this study was to validate MRNMAP. Section 4.2 contains two input files that were used during the model development to test algorithms in MRNMAP.

4.1 China Lake Model Validation

4.1.1 Radar Data and Analysis

Between 13 April 1994 and 21 July 1994 radar data were provided by the NAWC China Lake Computer Systems Branch, Code 525400D. The radar data were used to determine the spatial distribution of flight tracks and the delivery profiles. Ten days of noise monitoring were performed during this sampling period.

The radar site used in this study is located near the Inyokern Municipal Airport. The antenna's latitude and longitude are 35°39'26"N and 117°50'15"W, respectively. The radar is located approximately 7.5 nautical miles from the Baker Range. There are no obstacles between the radar and the range that would prevent the radar from tracking aircraft close to the surface.

Table 4-1 shows the number of fixed- and rotary-wing aircraft that were recorded during the radar data collection period. Not all of the aircraft types shown in the table used the range. For example the C-130, tracked 31 times during the sampling period, did not use the Baker Range. Most of these operations were either arrivals to or departures from the airfield.

Analysis of the radar data required the development of six computer programs to process the data. Figure 4-1 is a flowchart showing the data analysis process. Each block appearing in the figure represents a computer program. The arrows show the order of the analysis and the data files that were passed between each of the programs.

Table 4-1

Number of Fixed- and Rotary-Wing Aircraft
Recorded on Radar During the Period of
13 April 1994 Through 21 July 1994

Aircraft Type	**Number Recorded on Radar**
F-18	305
AV-8	84
H-1	70
A-6	40
F-14	39
C-130	31
F-4	24
A-4	14
H-60	3

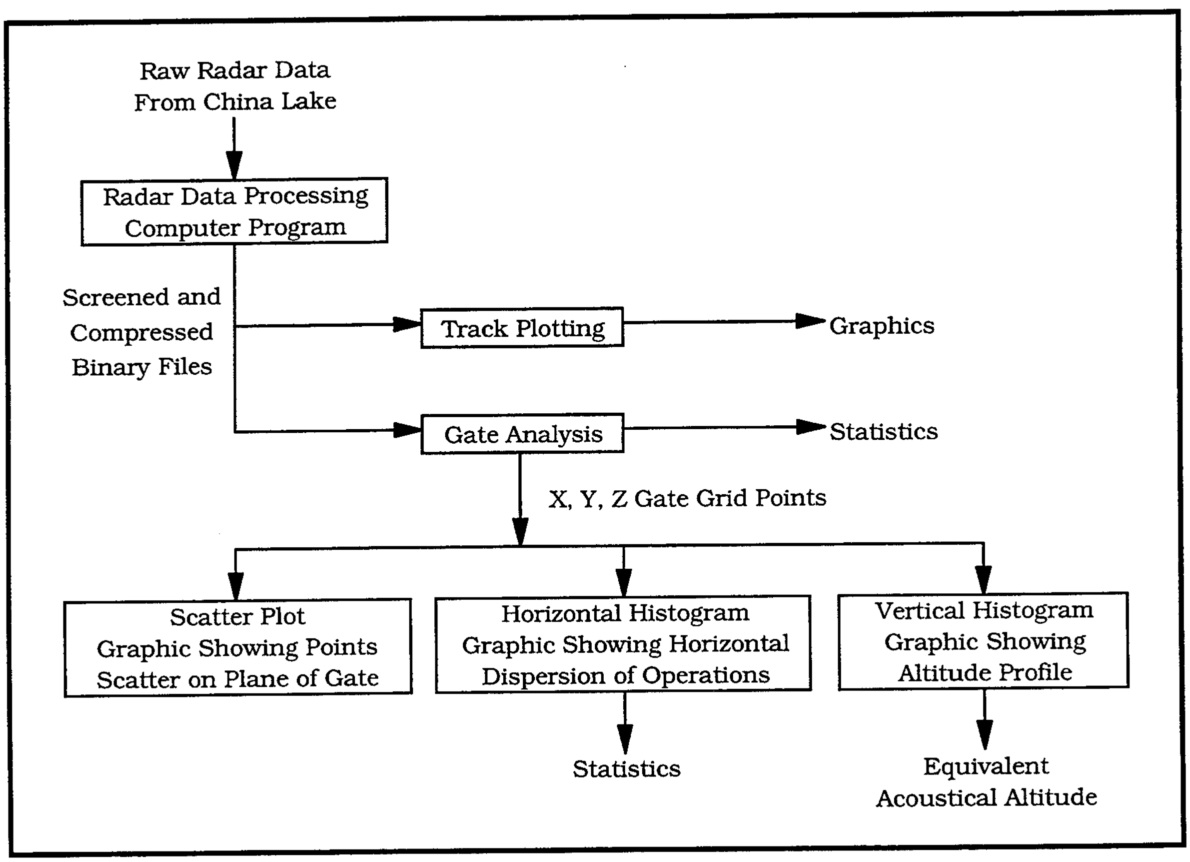


Figure 4-1. Flowchart of Radar Data Analysis.

The radar data, provided by NAWC China Lake, came in two file formats. The first file contained the radar azimuth, the distance from the radar to the aircraft, the time, and the beacon code. The second file contained a listing of the beacon codes and the aircraft type. The processing computer program read both file formats, collated the data, and screened the data for errors. The program output a compressed binary file that was used in all subsequent data processing. Fifty-seven packed binary files were created from the raw radar data. Each binary file represents one day of sampling.

All of the data provided by NAWC China Lake was screened for errors. If an error was detected, the data was eliminated from the sample. The most frequent source of error was due to an incomplete or corrupt data field. More than 90 percent of the data passed all of the screening tests.

The binary files are then read by two computer programs. The first program plots the ground tracks. The track plotting program has the capability of filtering the ground tracks by altitude range and aircraft type. The second program is used to develop a two-dimensional representation of the vertical and horizontal distribution of the flight activity. The program conceptually makes a vertical slice of the tracks and writes a file that contains the X,Y,Z intercept points. The program reads the binary tracking data for each sortie, determines the exact position of the aircraft as it intersects the plane of the gate, and writes a file containing the intercept points. The program also calculates the number of day, evening, and night operations; and the number of times an individual airplane passes through the gate. The latter quantity is useful for determining the number of passes that an individual aircraft makes on a weapons delivery run.

The file containing the X,Y,Z intercept points is read by three computer programs. The first program plots the grid points as they appear on the plane of the gate. This plot, sometimes called the scatter plot, is useful in identifying horizontal or vertical dispersion patterns. The second program plots a histogram of the horizontal dispersion. This program is used on tracks where it is necessary to determine if the aircraft are Gaussian distributed and, if so, the mean and standard deviation. The third program plots the vertical distribution of the aircraft. This program also determines the aircraft equivalent acoustical altitude, which is used by MRNMAP.

The analysis of radar data shows that four major aircraft types utilize the Baker Range. These are the F-18, AV-8, A-6, and F-14 military aircraft. Each of these aircraft was analyzed using the process described in Figure 4-1. The analysis showed that the operations on the range can be modeled as a combination of tracks and distributed operations. Tracks are modeled as a Gaussian distribution of line sources. Distributed operations are modeled as a uniform spatial distribution of operations and is applied to areas where the aircraft do not follow a predominant track but are randomly distributed.

Contained in Appendices D and E are plots of the aircraft ground tracks at selected altitude ranges for the four types of military aircraft. Appendix D shows all of the data collected over the 90-day period. Appendix E contains the radar tracking data collected during the ten-day noise monitoring period only.

Based on the data shown in Appendix E, tracks and models of quasi-MOAs were developed to represent the different types of flight activities. These airspace models, shown in Appendix F, are entered directly into MRNMAP. Activity levels are assigned to each airspace component these are based on the statistical information derived by using "gates" to organize the data. Details of the altitude profiles and the frequency of operations assigned to the individual airspace components are contained in the input files to MRNMAP.

4.1.2 Noise Measurements

For purposes of collecting the necessary source level noise data for MRNMAP and to compare the measured aircraft noise levels to the predicted levels, an aircraft noise monitoring program was performed.

Between 8 June 1994 and 17 June 1994, continuous noise monitoring data was collected at NAWC China Lake. Shown in Table 4-2 are the number of aircraft, recorded by radar, during the noise monitoring period. There was a total of 73 sorties reported by the radar during the ten-day monitoring period. Aircraft were reported in the vicinity of NAWC China Lake during six of the ten days. The ground tracks for the F-18, AV-8, and A-6 are shown in Appendix D. The ground tracks for the F-14 are not included in Appendix D since these operations were mostly confined to arrivals or departures from Armitage Field.

Table 4-2

Number and Type of Aircraft That Used The Range
During the Noise Monitoring Period

Dates	Number of Aircraft Recorded by Radar During Noise Monitoring Period					
	F-18	AV-8	A-6	F-14	Other	Total
8 June	7	3	1	0	3	14
9 June	3	1	0	0	1	5
10 June	1				1	2
13 June	0	4	1	0	4	9
14 June	8	5	1	6	2	22
16 June	5	4	0	2	10	21
TOTAL	24	17	3	8	21	73

Other = A-4, H-1, F-4, F-16.

Thirteen noise monitors were located on the Baker Range and six monitors were located at the Armitage Field. Shown in Table 4-3 are the monitors' latitude and longitude coordinates. These values were obtained using a Global Positioning System (GPS).

Table 4-3

Locations of Noise Monitors

Site		Latitude (Deg. N)	Longitude (Deg. W	Cartesian Coordinate*	
				X (Feet)	Y (Feet)
Baker Range	1	35.775917	117.792139	13,420	43,320
	2	35.776528	117.788056	14,630	43,540
	3	35.775972	117.783889	15,860	43,340
	4	35.714722	117.769194	20,210	20,985
	5	35.716389	117.765417	21,325	21,595
	6	35.717444	117.761611	22,450	21,980
	7	35.776389	117.840833	-985	43,490
	8	35.697167	117.811611	7,660	14,580
	9	35.654444	117.795361	12,465	1,015
	10	35.658389	117.726111	32,955	425
	11	35.658056	117.711778	37,195	305
	12	35.659306	117.669028	49,845	760
	13	35.663194	117.637917	59,050	2,180
Armitage Field	20	35.697611	117.680306	46,505	14,740
	21	35.698778	117.681500	46,155	15,165
	22	35.699889	117.682583	45,830	15,570
	23	35.671528	117.712250	37,055	5,220
	24	35.672417	117.713806	36,595	5,545
	25	35.670250	117.710694	37,515	4,755

* Coordinate relative to the radar site, which was given as 35.657222°N, 117.8375°W.

A Larson-Davis Model LD-820 sound level meter was placed at each monitoring site. This instrument is a Type 1 precision sound level meter. The microphone used was a Bruel & Kjaer Model 4176 pre-polarized condenser microphone.

During the monitoring period, each site was visited at least once every two days. When a site was visited, the noise monitor was connected to a portable computer which downloaded the noise data and set the monitor clock so that it was synchronized with the radar clock. The threshold sound level on the sound level meter was set to 65 dBA. When a noise event exceeded the threshold level the monitor recorded the Maximum A-Weighted Sound Level (L_{max}), the SEL, the peak sound level, and the time. There were more than 5,000 individual aircraft noise events recorded on the Baker Range and 1,000 noise events recorded from the monitors positioned near Armitage Field.

The noise monitoring data were analyzed using a computer program that correlates radar data to noise monitoring data. The program systematically steps through the radar data calculating an aircraft's point of closest approach to each of the noise monitors. The noise data is checked by the program to determine if a measurement was made and if the radar time agrees with the noise event time. The program further screens the tracking data to determine if any other aircraft are in the area. If the times agree and if there is only one aircraft in the area, the noise data and slant distance is recorded by the program for future processing.

Using a commercial curve-fitting software, it was determined that with minimal error the shape of the curves of SEL versus distance in the NOISEFILE database as computed by OMEGA10 can be of the form:

$$SEL = A + B \times \sqrt{\text{Slant Distance}} \tag{4-1}$$

where the slant distance is in thousands of feet.

Using the curve-fitting software, the measured SEL data and the calculated slant distances for each aircraft type were fit to Equation (4-1) – that is, the coefficients A and B were determined from each set of data. Given in Table 4-4 are the coefficients for the F-18, AV-8, and A-6 aircraft. Using Equation (4-1) and the coefficients appearing in Table 4-4, the curves are tabulated in Table 4-5 and are shown in Figures 4-2, 4-3, and 4-4 for each aircraft type. In these figures all the data collected on the range and near the airfield for a given aircraft type were

Table 4-4

SEL Versus Slant Distance Empirical Formulation

$SEL = A + B\sqrt{\text{Slant Distance (Thousands of Feet)}}$		
Aircraft	**Coefficients**	
	A	**B**
F-18	120.9371	-14.24829
AV-8	110.74001	-11.094783
A-6	124.06017	-15.772639

Table 4-5

Source Level Data Used With MR_NMAP
as Computed From Table 4-4

Distance (Feet)	**A-Weighted Sound Exposure Level (dB)**		
	F-18	**AV-8**	**A-6**
100	116.4	107.2	119.1
125	115.9	106.8	118.5
160	115.2	106.3	117.8
200	114.6	105.8	117.0
250	113.8	105.2	116.2
315	112.9	104.5	115.2
400	111.9	103.7	114.1
500	110.9	102.9	112.9
630	109.6	101.9	111.5
800	108.2	100.8	109.9
1,000	106.7	99.6	108.3
1,250	105.0	98.3	106.4
1,600	102.9	96.7	104.1
2,000	100.8	95.0	101.8
2,500	98.0	93.2	99.1
3,150	95.6	91.0	96.1
4,000	92.4	88.5	92.5
5,000	89.1	85.9	88.8
6,300	85.2	82.9	84.5
8,000	80.6	79.3	79.4
10,000	75.9	75.6	74.2
12,500	70.6	71.5	68.3
16,000	63.9	66.4	60.9
20,000	57.2	61.1	53.5
25,000	49.7	55.3	45.2

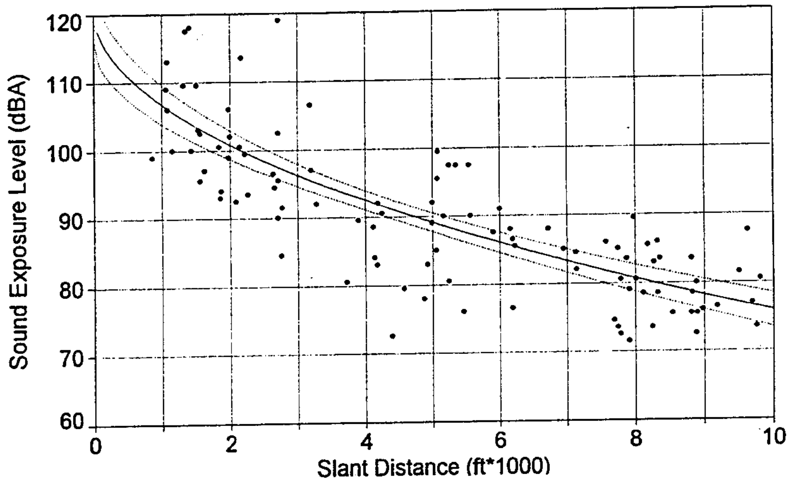


Figure 4-2. Sound Exposure Level Versus Slant Distance for the F-18.

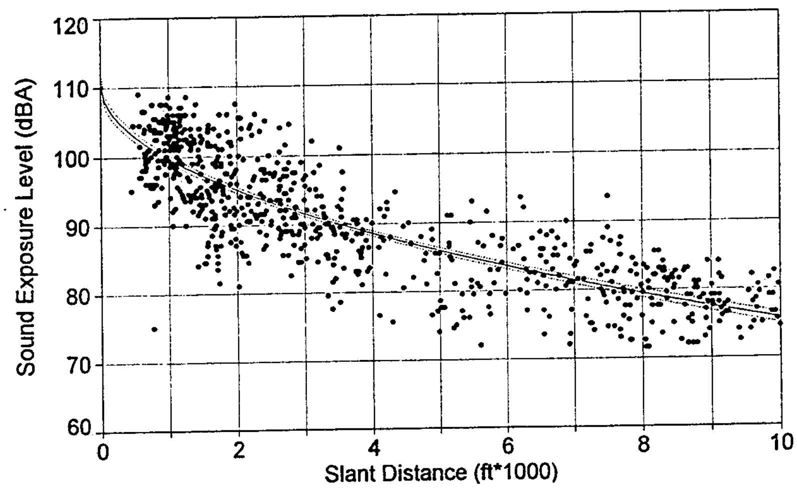


Figure 4-3. Sound Exposure Level Versus Slant Distance for the AV-8.

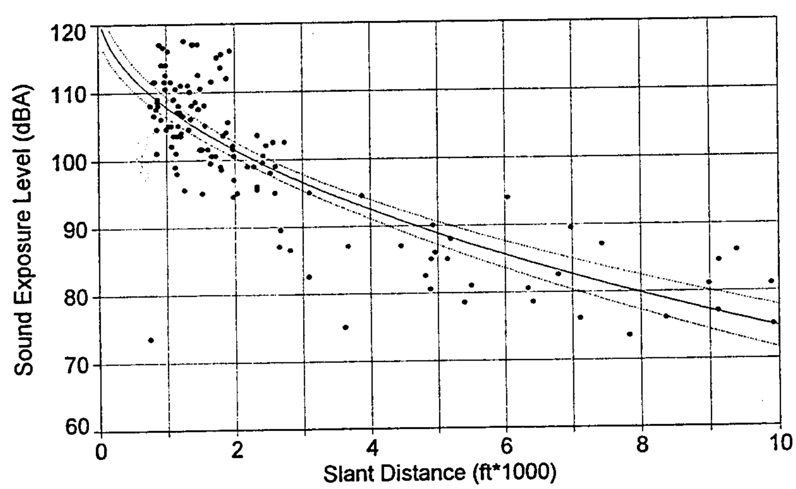


Figure 4-4. Sound Exposure Level Versus Slant Distance for the A-6.

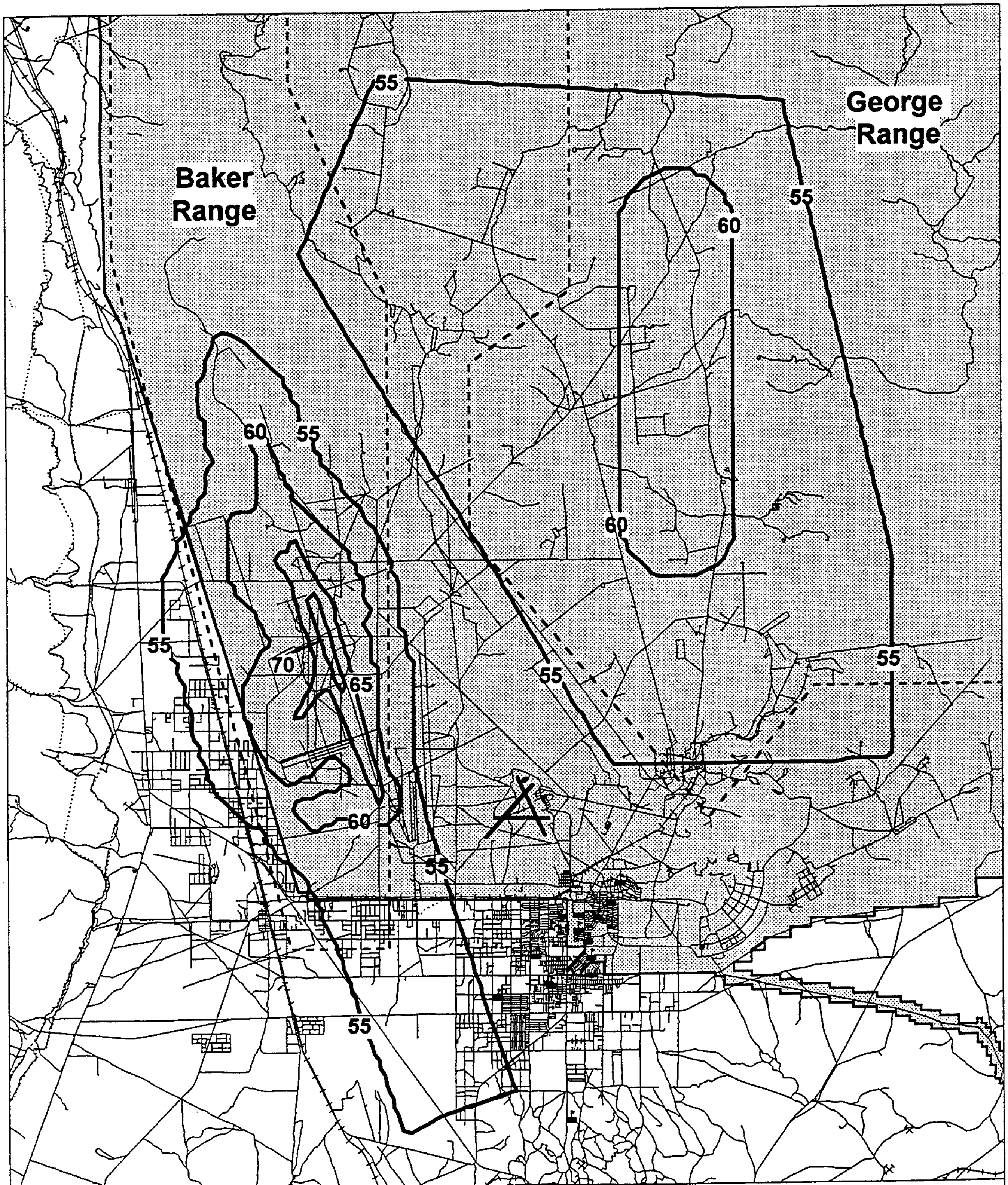
combined onto a single plot. This was done because the range and airfield data were found to be very similar. As evidenced by the somewhat even distribution of the data points about the solid lines in each of the figures, the measured noise levels are concluded to follow the same trend as the data computed using the OMEGA10 computer program. The values shown in Table 4-5 were entered directly into MRNMAP and represent average noise level under average power and speed conditions for Range operations.

4.1.3 Validation

The radar data collected during the noise monitoring period were analyzed to determine the number of sorties on the Baker and the George ranges. Also determined from the data was the number of passes flown over the target area and the amount of time spent in each of the modeled quasi-MOAs. These values were combined with the flight track and distributed operations models developed in Section 4.1.2 to prepare a set of CNEL contours for the range. The results from this analysis are shown in Figure 4-5. The contours shown in this figure do not factor in the noise due to operations from the Armitage Field; nor do they include the noise from the explosion of spotting charges on the range, vehicular traffic, or other forms of human activity.

Figure 4-6 depicts the combined CNEL contours from airspace (MRNMAP) and airfield (NOISEMAP) activity for the noise monitoring period only. The airfield contours are based on the average busy-day for calendar year 1993 which is representative of the average sound levels during the nine-day measurement period. The measured sites are indicated.

Table 4-6 shows a comparison between the measured and predicted noise levels for each of the noise monitoring sites. Noise measurements were only made on the Baker Range and area surrounding the Armitage Field. The measured values are Equivalent Average Sound Levels (L_{eq}). These are equivalent to CNEL since there were no evening or nighttime operations on the range during the monitoring period. The table is divided into three parts. The first part represents noise monitoring sites that measured noise resulting primarily from Baker Range operations. The second part represents noise monitoring sites that measured noise from range and airfield operations. The third part represents noise monitoring sites that measured exclusively airfield operations. The agreement between measured and predicted levels is



Scale

0 10000 20000
Feet

N

Legend

NAWC China Lake
-55- CNEL Contour
Hospitals
Schools
--- Range Boundary

Figure 4-5
NAWC China Lake
CNEL Contours
Range Operations
8-June-94 to 17-June-94

Source: DOD MR. NMAP 1.0
Prepared by Wyle Laboratories, 1995

Scale

0 6000 12000

Feet

N

Legend

NAWC China Lake

—60— CNEL Contours

Hospitals

Schools

1 ◆ Noise Monitor Locations

Figure 4-6

NAWC China Lake
CNEL Contours
Armitage Field and Range Operations
8-June-94 to 17-June-94

Source: DOD NOISEMAP 6.3 and MR_NMAP 1.0
Prepared by Wyle Laboratories, 1995

fig3-14

shown to be within 2 dB for six of the 16 monitoring sites. Sites 1 through 9, which were dedicated to measuring range operations, are all within 3 dB of the predicted noise levels.

Table 4-6

Comparison Between Measured and Predicted Noise Levels

Noise Monitor Site		Measured CNEL* (dB)	Predicted CNEL (dB)	Difference Between Measured and Predicted (dB)
Range	1	71	69	+2
	2	68	68	0
	3	63	66	+3
	4	69	66	+3
	5	68	67	+1
	6	61	63	-2
	7	59	59	0
	8	60	59	+1
	9	57	54	+3
Range and Airfield	10	68	63	+5
	11	67	68	-1
	12	65	68	-3
	13	52	54	-2
Airfield	20	73	78	-5
	21	83	80	+3
	22	74	79	-5
	23	73	73	0
	24	76	72	+4
	25	75	72	+3

* Since there were no evening or nighttime events during the measurement period, this is equivalent to the 24-hour Leq.

The time duration of the noise monitoring period varied between the sites. At sites 1 through 13, the time duration ranged between 150 to 200 hours, depending on the site. All 13 sites were operational during the six days when aircraft were on the range. Thus the noise contours shown in Figure 4-5 assume a six-day integration period. The noise monitors at sites 20 through 25 were located near the airfield. At these sites, the noise monitors recorded the noise levels for two busy-days between 0700 and 1900 hours. The NOISEMAP calculations are based on an average busy-day for calendar year 1993. This does not accurately represent the actual number of operations flown during the two-day measurement period and is the reason for the large differences between measured and predicted noise levels in Table 4-6 under the Airfield heading.

4.2 Test Cases

Two test cases have been prepared to check the algorithms in MRNMAP. Both input files appear in Appendix G. The first test case, shown in Figure 4-7, compares predictions made by NOISEMAP with MRNMAP. The example is based on a P-3, under cruise conditions (2000 ESHP and 180 knots), making 125 daily operations around a track. The track altitude varies between 500 and 2,000 feet AGL, as shown in the sketch, and in one of the turns transitions from 2,000 to 500 feet AGL. The "wavy" contours in Figure 4-7 are due to the contouring program NMPLOT, which interpolates contour levels from a flight track that are not aligned with the calculating grid.

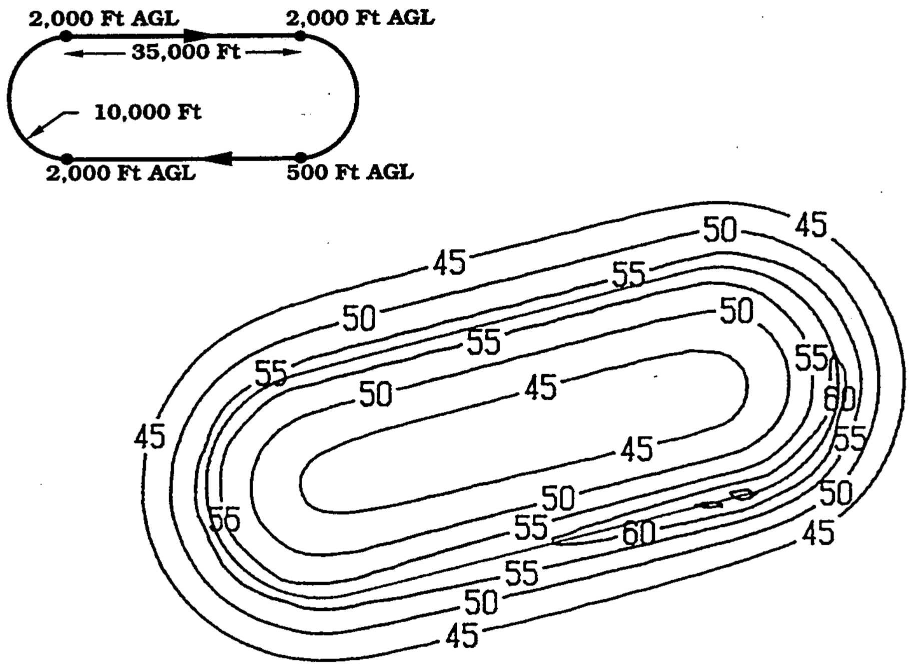
The second test case checks algorithms developed to model distributed operations. The input file has been processed four times, each time a different value for the standoff distance was used. The input file contains four overlapping shapes – see Figure 4-8. Each shape checks specific routines in the noise model. The triangle denoted as "A" is used to check small angles. If the routine is working properly, contours should wrap around the corners at uniform distances. The square labeled "B" checks the grid values in MOAs that share a common boundary. The grid values should be the same on both sides of the boundary shared by the "B" and "D" MOAs. The shape labeled "C" checks avoidance areas that are located on the inside and the outside corners of the MOAs. The contours should decrease where the MOA and avoidance areas overlap, and then further decrease inside the avoidance area, at the MOA edge.

Table 4-7 contains the areas for the noise contours calculated at different standoff distances. As expected, the areas are shown to decrease as the standoff distance is increased. The energy-average noise level remains the same for all four cases; however, the noise level at the center of each of the MOAs increases with increasing standoff distance.

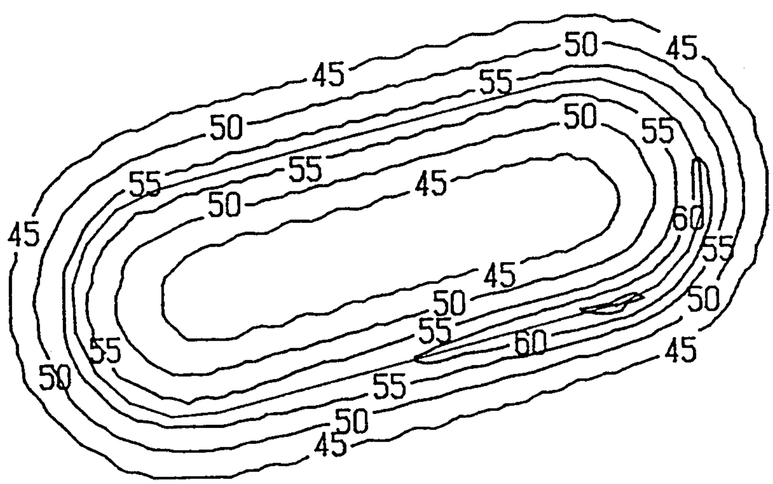
Table 4-7

Contour Areas for Distributed Operations
Test Pattern in Square Miles

Contour Level (dB)	Standoff Distance			
	0 nm	**1 nm**	**2 nm**	**5 nm**
45	117	85	84	82
50	101	80	78	75
55	83	64	61	52
60	51	41	32	25

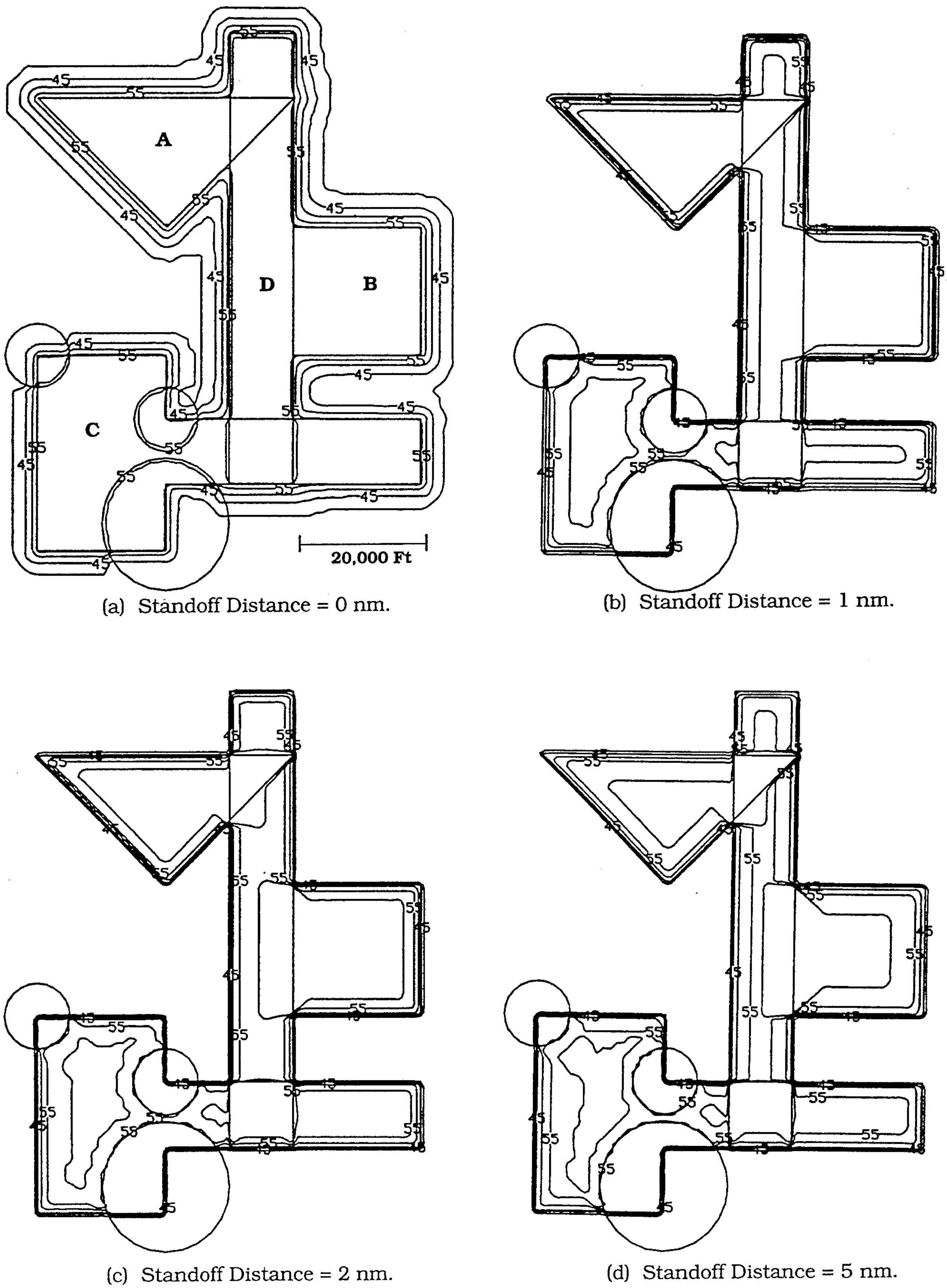


(a) NOISEMAP Prediction.



(b) MR_NMAP Prediction.

Figure 4-7. Comparison Between NOISEMAP and MRNMAP Predictions.



(a) Standoff Distance = 0 nm.

(b) Standoff Distance = 1 nm.

(c) Standoff Distance = 2 nm.

(d) Standoff Distance = 5 nm.

Figure 4-8. MRNMAP Distributed Operations Test Pattern.

5.0 PROGRAMMER'S GUIDE TO MRNMAP

This chapter reviews the organization and structure of the MRNMAP source code. Section 5.1 gives a description of the programming convention. Section 5.2 explains the program organization and describes each of the subroutines contained in MRNMAP. Section 5.3 describes compiling and linking procedures.

5.1 Program Convention and Organization

MRNMAP is written in FORTRAN 77. The source code makes extensive use of subroutines in order to provide reasonably well-structured code. Variable names are consistent between subroutines, although there are a few instances where the mnemonics are similar but not identical. Real variables are declared as single precision REAL*4. Fixed-point variables are declared as INTEGER*2 or INTEGER*4. All of the variable names are six characters or less. Executable statement labels begin with 10 in each program; format labels begin with 1000.

The source code for MRNMAP is contained in eight files. The source code for processing distributed operations is found in the files MOAMAP and MOASUB, while the source code for processing tracks is contained in the TRKMAP and TRKSUB files. The INPUT file contains subroutines used to read the input file and the file OTHERSUB is a catch-all for subroutines that do not logically fit into the other files. OMEGA10R contains a version of the OMEGA10 series program specifically tailored for military training routes. PLOTMR contains the routines that are used to write a binary grid file to NMPLOT.

5.2 Description of Subroutines

The MRNMAP subroutine hierarchy chart is shown in Figure 5-1. The main calling program, MRNMAP, appears in the first column on the left. To the right of the first column appear the subroutines organized according to the calling sequence from the main program. The following subsections describe each of these subroutines. Section 5.2.1 discusses the subroutines contained in the file INPUT.FOR. Section 5.2.2 discusses the subroutines that are contained in the file OTHERSUB.FOR. Section 5.2.3 describes the subroutines contained in the file MOAMAP.FOR and Section 5.2.4 describes the subroutines contained in the file TRKMAP.FOR. The subroutines appearing under each of these subsections are arranged in the same order as they appear in their respective files.

- MRNMAP
  - GETSEL
    - FGETENV
    - OMEGA
  - GRID
  - INPUT
    - ALLCAP
    - ASPEC
      - ALLCAP
      - DISPLAY
    - AVD
      - ALLCAP
      - DISPLAY
    - DISPLAY
    - LATLNG
      - DISPLAY
    - MIS
      - ALLCAP
      - DISPLAY
    - MOPS
      - ALLCAP
      - DISPLAY
      - SORT10
      - SORT25
    - MSPEC
      - ALLCAP
      - DISPLAY
    - RAWSEL
      - ALLCAP
      - DISPLAY
      - SORT10
    - SPARA
      - DISPLAY
    - SPOINT
      - ALLCAP
      - DISPLAY
    - TOPS
      - ALLCAP
      - DISPLAY
      - SORT10
      - SORT20
    - TSPEC
      - ALLCAP
      - DISPLAY
  - LEVEL
  - LVL2PSQR
  - MOAMAP
    - EAA
      - EVENT
        - EPNLD
        - GAUSS
        - LOOKLVL
      - LOOKLVL
      - LOOKSLT
    - INTERS
      - BNDY
      - PLANIM
        - ATRIG
    - MOACAL
      - EPNLD
      - LOOKLVL
      - RATADJ
    - PLANIM
      - ATRIG
    - RHRULE
    - SPARGERE
      - BNDY
      - CAMBIO
      - TAPER
        - BNDY
  - PLOTMR
    - IWSTRLEN
    - PUTDECM
      - PUTINTEGER
      - PUTLITERAL
    - PUTINTEGER
    - PUTLITERAL
    - PUTNAME
    - PUTNAME
    - PUTSTRING
  - RESULT
  - SELTAB
  - SPANA
  - TRKMAP
    - EAA
      - EVENT
        - EPNLD
        - GAUSS
        - LOOKLVL
    - IWORK
    - LMAXTRK
      - BNDY
      - CORNER
      - LATATN
      - LOOKLVL
    - NMAP
      - BNDY
      - CORNER
      - EPNLD
      - LINESEG
      - LOOKLVL
      - RATADJ
    - RTMAP
      - BNDY
      - CORNER
      - FDMI
      - RTCALC
        - GAUSS
        - LATATN
        - LOOKLVL
        - RATADJ
    - SPREAD
      - BNDY
      - CORNER
      - EPNLD
      - GAUSS
      - LOOKLVL
      - RATADJ
      - RTCALC
        - GAUSS
        - LATATN
        - LOOKLVL
        - RATADJ
    - TURNSEG

Figure 5-1. Subroutine Hierarchy Chart, MRNMAP.

5.2.1 Subroutines Contained in the File INPUT.FOR

5.2.1.1 INPUT

This subroutine is the main calling routine for reading airspace and operation data into MRNMAP. The subroutine reads the input file (filename.INP), one line at a time. Each line is compared to the 31 possible keywords. If a keyword is used to enter airspace or operation data into MRNMAP, then subroutine INPUT calls a subroutine to read the keyword data. If a keyword is used to signal a computational or reporting feature to MRNMAP, then subroutine INPUT sets the appropriate array element in variable FLAG equal to TRUE. Shown in Table 5-1 contains the FLAG definitions. When MRNMAP encounters the END keyword or an end-of-file marker, subroutine INPUT echoes the input data to the text (filename.TXT) file. A string of data not recognized by INPUT as a keyword is ignored. A description of the keyword format is contained in Appendix C.

Table 5-1

List of Keywords to Set Logical Array "Flag" Equal to a True Condition

"Flag" Array Location Number	**Keywords**
1	DIAGNOSTICS
2	NO REPORT
3	SEL
4	LEQ
5	LMAX
6	CNEL
7	LDN
8	ONLY TRACK
9	ONLY MOA
10	NO GRID
11	TAPER 1
12	TAPER 2
13	TAPER 5
14	SELR or LDNMR

5.2.1.2 ALLCAP

This subroutine strips the input string of all leading blank characters and exchanges lowercase characters for uppercase characters. This subroutine is called each time a character string is read from the input file.

5.2.1.3 SPARA

This subroutine reads the setup parameters that follow the SETUP PARAMETER keyword. All data is read using a free-formatted read statement.

5.2.1.4 MSPEC

This subroutine reads the MOA specification data that follow the MOA SPECIFICATION keyword. All the X and Y coordinate values, which define the boundaries of the MOA, are subtracted from the lower left corner of the grid in this subroutine.

5.2.1.5 ASPEC

This subroutine reads the MOA area, floor, and ceiling that follow the AREA SPECIFICATION keyword. The subroutine sets variable MOASEG equal to 999 which will signal to the calculating routines to use the MOA area supplied by the user as opposed to calculating the MOA area from the boundary points.

5.2.1.6 TSPEC

This subroutine reads the track specification data that follow the TRACK SPECIFICATION keyword. The track name may be up to 20 characters in length. The maximum permissible length of a track is 50 turn points. MRNMAP will accept up to 25 separate tracks. All the X and Y coordinates, which define the location of the turn points, are subtracted from the lower left corner of the grid.

5.2.1.7 SPOINT

This subroutine reads the specific points that follow the SPECIFIC POINT keyword. A specific point name can be up to 20 characters in length and the maximum number of specific points is 25. All the X and Y coordinates which define the specific point location are subtracted from the lower left corner of the grid.

5.2.1.8 AVD

This subroutine reads the avoidance area data that follow the AVOIDANCE keyword. An avoidance area name can be up to 20 characters in length and the maximum number of avoidance areas is 25. All X and Y points which reference the center of the avoidance area are subtracted from the lower left corner of the grid.

5.2.1.9 MISS

This subroutine reads the aircraft code, power and speed setting, and the altitude profile which follow the MISSION keyword. A mission name can be up to 10 characters in length and the maximum number of missions is 50. The variable numMIS is a counter that is incremented once each time this subroutine is called.

5.2.1.10 RAWSEL

This subroutine is used to read the noise level versus distance data that follow the IMPORT SEL keyword. This keyword is used in place of the NOISEFILE acoustical data set. The noise data is entered at the same slant distances OMEGA10R uses. The subroutine first reads the air-to-ground noise levels then reads the ground-to-ground levels. These values are stored in variable names SELAG and SELGG. SEL data for a maximum of 50 missions may be specified using this keyword. If an LMAX keyword appears in the input file, then the numeric data read by this subroutine will be interpreted as L_{max} values.

5.2.1.11 MOPS

This subroutine is used to read the operations data that follow the MOA OPS keyword. The subroutine has two parts. The first part reads the name of the airspace and the percent utilization. Subroutine SORT25, called from this routine, compares the airspace name read under the MOA OPS keyword to the airspace names read under the MOA SPECIFICATION keyword. When a match is found, variable IPOINT is returned with a value that points to the current airspace position in the variable array MOANAM. When a match is not found, the program terminates with an error message. The second part of the subroutine reads the mission name, the number of operations, and the time an aircraft spends in the airspace per sortie. Subroutine SORT10, called from this routine, compares the mission name under the

MOA SPECIFICATION keyword to the mission name under the MISSION keyword. When a match is found, the subroutine proceeds with multiplying the operation data by the percent utilization for each of the airspace components. When a match is not found, the program terminates with an error message.

5.2.1.12 TOPS

This subroutine is used to read the operation data that follow the TRACK OPS keyword. The subroutine has two parts. The first part reads the name of the airspace and the percent utilization. Subroutine SORT20, called from this routine, compares the name of the airspace appearing under the TRACK OPS keyword to the airspace names read under the TRACK SPECIFICATION keywords. When a match is found, SORT20 returns with a value through IPOINT that points to the current airspace position in the variable array TRKNAM. When a match is not found, the program terminates with an error message. The second part reads the mission name and the number of operations. Subroutine SORT10, called from this routine, compares the mission name under the TRACK SPECIFICATION keyword to the mission name under the MISSION keyword. When a match is found, the subroutine proceeds with multiplying the operation data by the percent utilization for each of the airspace components. When a match is not found, the program terminates with an error message.

5.2.1.13 LATLNG

This subroutine reads the latitude and longitude appearing under the LOCATION keyword. The lower-left and upper-right corner of the grid are specified by MROPS in terms of their latitude and longitudes. MRNMAP reads the lower-left corner of the grid as a string and converts the latitude and longitude to REAL*8.

5.2.1.14 SORT10

This subroutine compares the name of the mission read under the MOA OPS or TRACK OPS keyword to the mission names listed under the MISSION keywords. When a match is found, SORT10 returns through variable IPOINT an integer value that points to the current mission position in the variable array NAME. When a match is not found, the program terminates with an error message.

5.2.1.15 SORT20

This subroutine compares the name of an airspace read under the TRACK OPS keyword to the airspace names listed under the TRACK SPECIFICATION keywords. When a match is found, SORT20 returns through variable IPOINT an integer value that points to the current airspace position in the variable array NAME. When a match is not found, the program terminates with an error message.

5.2.1.16 SORT25

This subroutine compares the name of an airspace read under the MOA OPS keyword to the airspace names listed under the MOA SPECIFICATION keywords. When a match is found, SORT25 returns through variable IPOINT an integer value that points to the current airspace position in the variable array NAME. When a match is not found, the program terminates with an error message.

5.2.1.17 DISPLAY

This subroutine outputs the string of text, read from the input file, that caused the program to terminate with a read error. ICOUNT points to the input file line number that caused the program to terminate.

5.2.1.18 RESULT

This subroutine writes the results, to filename.TXT file in tabular form.

5.2.2 Subroutines Contained in File OTHERSUB.FOR

5.2.2.1 BNDY

This function determines if a grid point is inside or outside a boundary defined by a maximum of 25 grid points. If the grid point is inside the boundary, the logical variable BNDY is returned with a true value.

5.2.2.2 EAA

This subroutine calculates the effective acoustical altitude (EAA) using the altitude profile specified under a MISSION keyword. The first part of the subroutine checks that the altitude distribution increases positively and is contiguous from one

altitude band to the next. If these conditions are not satisfied, subroutine EAA will terminate with an error message. The second part of the subroutine calculates the total percentage of operations that are above the airspace floor and below the ceiling. When the altitude profile is <u>below</u> the floor, the subroutine returns a value for the EAA equal to the airspace floor. When the altitude profile is <u>above</u> the ceiling, the subroutine returns a value equal to the airspace ceiling. The third part of the subroutine calculates the sound level directly under the flight track. The calculation is limited to those operations that are between the floor and the ceiling. The sound level is entered into an SEL versus slant distance look-up table to determine the altitude that will produce an equivalent sound level. This altitude becomes the effective acoustical altitude or EAA.

Before returning to the calling program, subroutine EAA calculates the number of events over a pre-specified level. The computation is made through a call to subroutine EVENT.

5.2.2.3 EVENT

This subroutine calculates the number events over a pre-specified level. ILIMIT is the variable name for the pre-specified level. The calculation begins at a sideline distance from the track centerline determined by the ILIMIT contour. At this sideline distance, the lateral attenuation is calculated and subtracted from the current contour value. If the resulting level is less than ILIMIT, the current sideline distance is adjusted inward by 1,000 feet. The process iterates until a contour is found that is greater than ILIMIT. The sideline distance multiplied by the number of events at the current altitude is returned by this subroutine.

5.2.2.4 FGETENV

This subroutine is used to get the NOISE environment variable. The program makes use of two C functions, CHECKIT and GETENV. See Section 5.3 for instructions accessing the C libraries.

5.2.2.5 GETSEL

This subroutine gets the sound exposure levels (SEL). The program begins by writing a file called OUT. The file contains the aircraft types, powers, and speeds

which were specified under the MISSION keyword. Next, GETSEL calls a subroutine version of OMEGA10R that reads the OUT file. OMEGA10R writes a file called IN that contains the SEL values. GETSEL reads the SEL values contained in the IN file.

5.2.2.6 GRID

This subroutine calculates the number of rows and columns in the grid and, if necessary, will increase the grid spacing. The subroutine first tests the grid spacing specified by the user. If the grid exceeds the program memory limitations, the grid spacing is automatically increased to fit into the available memory. The program returns the value for the grid spacing and the number of rows and columns. A message will appear if the value for the grid spacing has been altered. To display the message insert a DIAGNOSTIC keyword into the input file.

5.2.2.7 LOOKLVL

This subroutine looks up the sound exposure level given the slant distance.

5.2.2.8 LOOKSLT

This subroutine looks up the slant distance given the sound exposure level.

5.2.2.9 SELTAB

This subroutine writes an SEL versus slant distance table to the text file. The table uses the same identical format that is used by the MENU10 computer programs. To display the table, insert a DIAGNOSTIC keyword into the input file.

5.2.2.10 SPANA

This subroutine performs a specific point analysis. The noise levels are interpolated between the grid points using a Bilinear surface calculation between the four adjoining grid points.

5.2.3 Subroutine Contained in FILE MOAMAP.FOR

Subroutine MOAMAP performs the noise calculations for MOAs and Ranges. Figure 5-2 flowcharts the overall structure of the subroutine and its calling

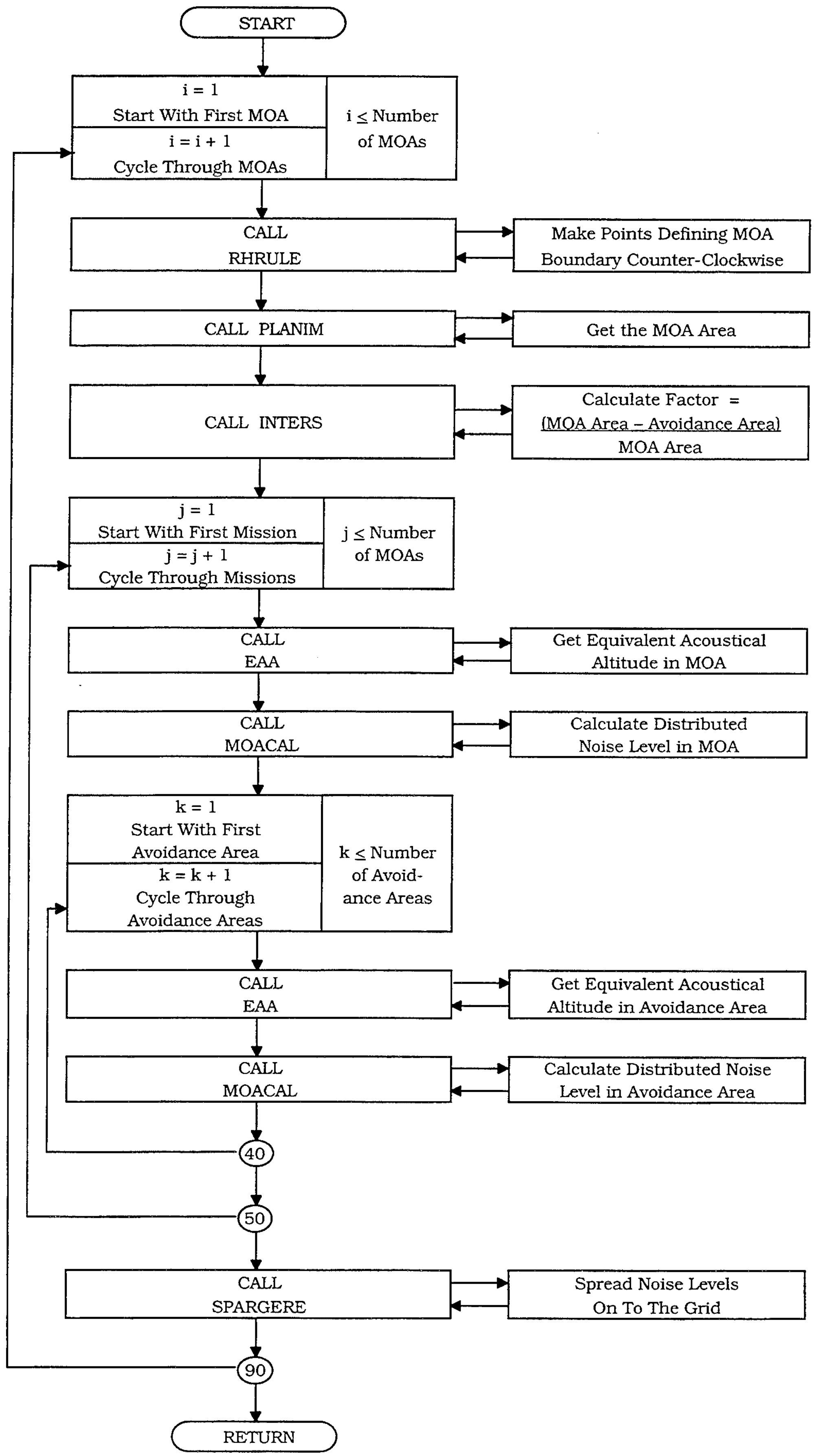


Figure 5-2. Flow Chart Diagram of Subroutine MOAMAP.

sequence. The subroutine contains three nested loops. The outermost loop (see DO loop number 90) steps through the MOAs. Nested inside this loop, the program steps through the mission profiles (see DO loop 50) and then the Avoidance Areas (see loop 40). Subroutine MOACAL is repeatedly called from subroutine MOAMAP. MOACAL is the main calculating routine for determining the noise levels due to distributed operations. A description of this subroutine is found in Section 5.2.4.4. SPARGERE is called once the average noise levels have been calculated. Its purpose is to distribute the noise levels onto the INTERGER*2 grid array called LEVEL. The values stored in LEVEL have been multiplied by a factor of 100 to preserve two places to the right of the decimal. LEVEL is the grid array from which noise contours are drawn.

5.2.4 Subroutine Contained in File MOASUB.FOR

5.2.4.1 ATRIG

This subroutine calculates the area for a triangle given three connecting points.

5.2.4.2 CAMBIO

This subroutine propagates the noise level outside a MOA's boundaries. The routine is called when the operations are uniform throughout the MOA and do not taper near the MOA edges. The routine decreases the sound levels, outside of the MOA, at a rate determined by the SEL versus distance relationship calculated for the operations inside the MOA.

5.2.4.3 INTERS

This subroutine calculates the area inscribed by the intersection of the avoidance area and the MOA. The subroutine returns a multiplying factor which is equal to the MOA area minus the intersecting area, divided by the MOA area.

5.2.4.4 MOACAL

This routine contains the core algorithm for calculating the noise level inside a volume of airspace. The subroutine uses the SEL versus ground distance table, based on the aircraft operating at an equivalent acoustical altitude, to determine the

distance separating the noise contours. These distances are multiplied by the time spent in the airspace and the actual speed of the aircraft. The result is the area of the noise contours swept out under the airspace. The energy-average is calculated by normalizing this area with respect to the total airspace area and summing over all contours.

5.2.4.5 PLANIM

This subroutine is an integrating algorithm that is used to calculate the area inside a region. The algorithm works like a planimeter. The points making up the region must be supplied as an ordered set. The pivot point must be located outside of the region for the subprogram to correctly sweep out the area.

5.2.4.6 RHRULE

This subroutine determines if a MOA's boundary points are ordered in the clockwise or counter-clockwise direction. If the boundary points are entered clockwise, the subroutine reverses their order. The algorithm is based on the application of the right-hand rule of vector cross-products.

5.2.4.7 SPARGERE

This subroutines spreads the noise contained within a MOA onto the grid. The subroutine systematically steps through each grid point and determines if the grid point is inside or outside the MOA boundary. If the grid point is inside the MOA or near its edges, then a noise level is added to the grid. Near the edges of the MOA, where the levels are expected to taper to a zero value, the subroutine decreases the noise levels according to the options specified by the user in the input file.

5.2.4.8 TAPER

This subroutine tapers the noise levels according to a linear decrease in aircraft population. The subroutine has two parts. In the first part, the subroutine determines if there are two adjoining MOA edges. If there are, then the levels calculated near this junction assume the operations are uniformly distributed. In the second part, it is assumed there are no adjacent MOAs. The calculation proceeds assuming that the population of the aircraft decrease at a linear rate beginning at the stand-off distance.

5.2.5 Subroutines Contained In File TRKMAP.FOR

5.2.5.1 TRKMAP

Subroutine TRKMAP performs the noise calculations for the track operations. Figures 5-3(a) and (b) show a flowchart of the subroutine. This subroutine offers many features that allow the user to model most situations encountered in special use airspace. These features include the modeling of: lateral dispersion, vertical dispersion, and turns with a dispersion component.

The subroutine has three nested do loops. The outermost loop steps through the noise calculations one track at a time (see DO loop 100). Nested within this loop, the calculations are repeated once for each mission profile (see DO loop 90) and then once for each track segment (see DO loop 40).

The calculations begin with a series of tests that determine if the operations are distributed and, if so, calculates the standard deviation. When the user has specified the route width, the standard deviation is calculated by multiplying the route width by 0.17 (see Reference 1).

Next the program tests if the turn point marks the beginning of a straight line segment or a turn. If it is a straight-line segment (see Figure 5-3(a)) the subroutine determines the effective acoustical altitude at either end of the line segment. If the operations are aligned along a single predominant track, a call is then made to NMAP. If the operations are distributed, and the standard deviations and the EAA do <u>not</u> change along the segment, then a call is made to RTMAP. Otherwise, the subroutine assumes the most general situation and makes a call to SPREAD.

When the turn point denotes the beginning of a turn (see Figure 5-3(b)), the program performs the same calculations as before, but in a slightly different order. The subroutine first calculates the EAA at either end of the turn. Next, the subroutine makes a call to TURNSEG, which partitions the turn into equal line segments. The calculations for a line segment, described above, are now applied on each of the straight-line segments. The altitude on each segment is adjusted so that the transition in altitude is linear throughout the turn.

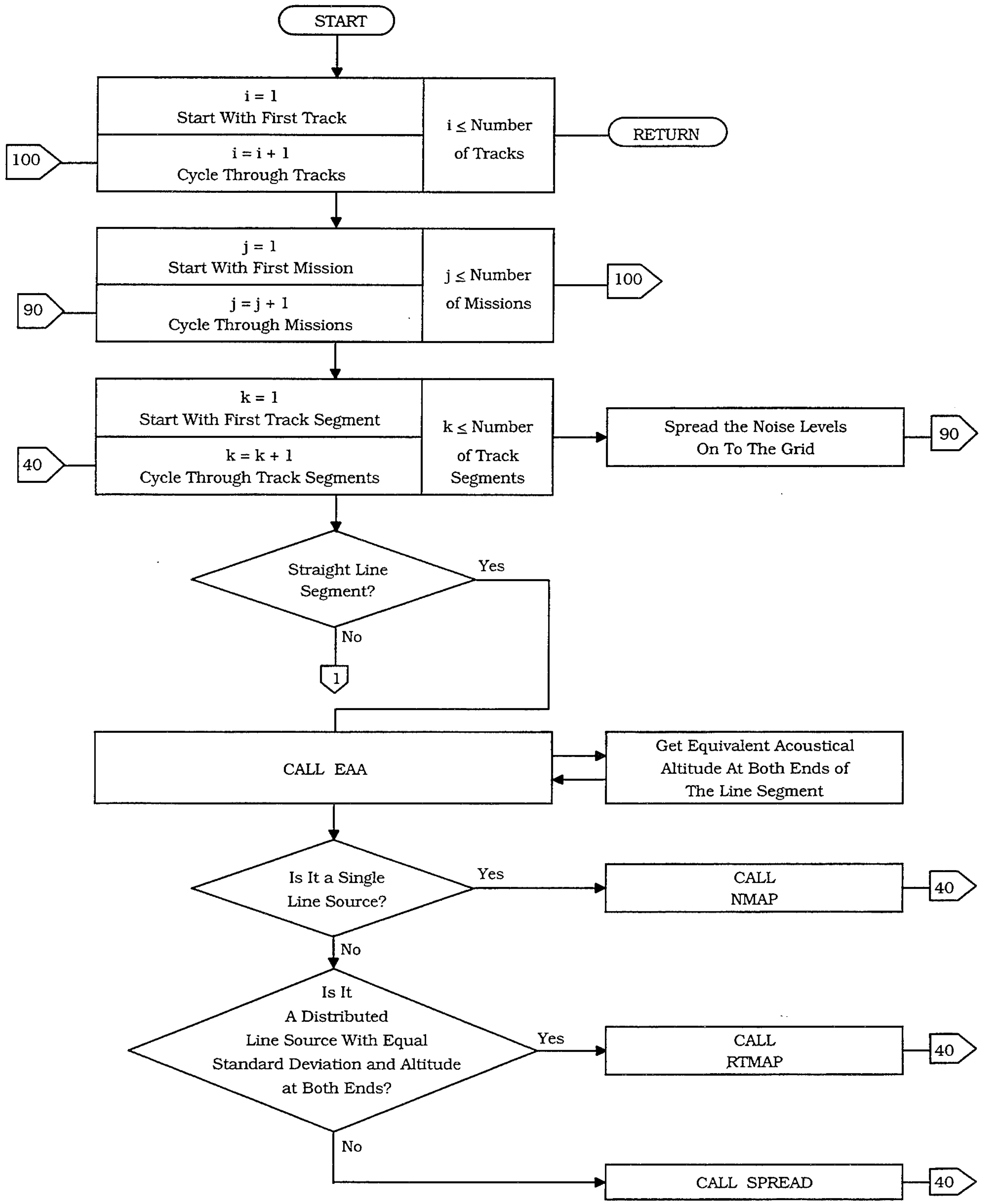


Figure 5-3(a). Flowchart Diagram of Subroutine TRKMAP.

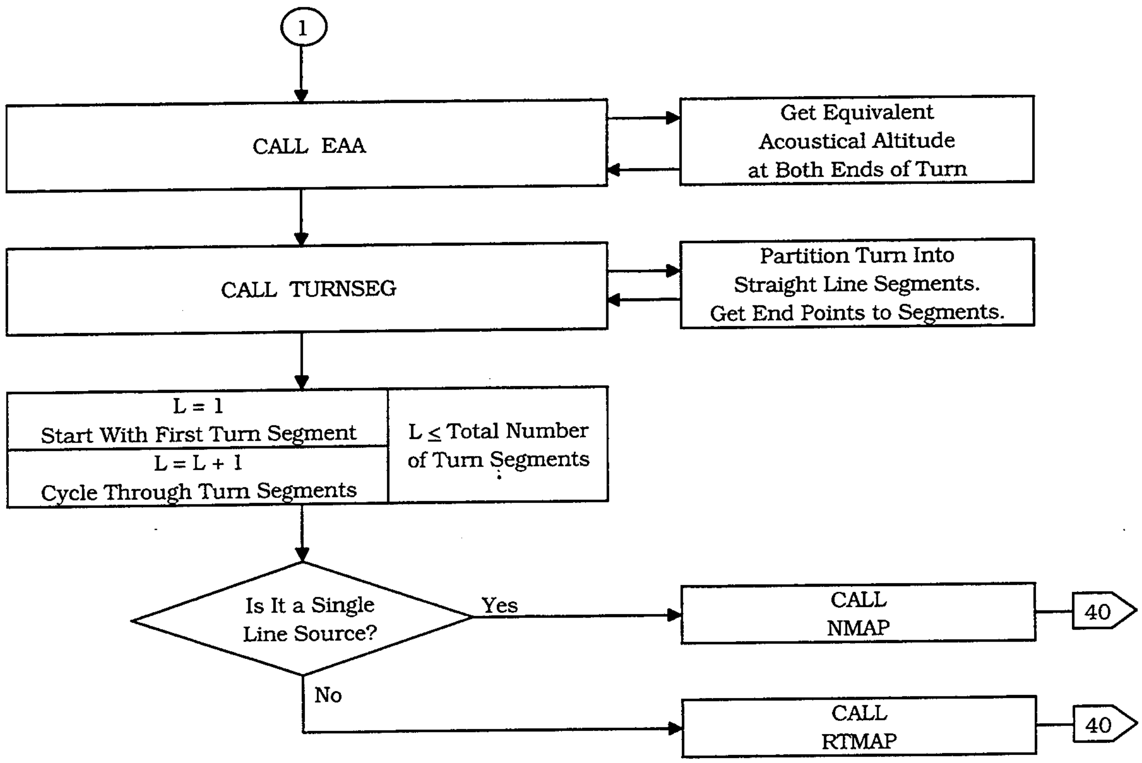


Figure 5-3(b). Flowchart Diagram of Subroutine TRKMAP (continued).

5.2.6 Subroutines Contained In File TRKSUB.FOR

5.2.6.1 CORNER

This subroutine calculates the corners of a nested grid located within the primary grid. A nested grid system is used when calculating the noise levels for an individual line segment. The grid system is sized so that the maximum sideline distance is at 10,000 feet from the line segment. A rotation and translation matrix is used in the subroutine to compute the four corners of the grid.

5.2.6.2 EPNL

This subroutine calculates the lateral attenuation using the same subroutine that is contained in NOISEMAP. The subroutine uses one of two methods to calculate the lateral attenuation, depending on the logical variable FLTSAE. If FLTSAE is .TRUE. then SAE AIR 1751 is used in the computations. If FLTSAE is .FALSE. then the program uses the NOISEMAP 6.0 algorithm. MRNMAP calls this routine with FLTSAE set equal to .FALSE.

5.2.6.3 FDMI

This subroutine is used to interpolate a numeric function tabulated at equal intervals. This is the same routine that is contained in ROUTEMAP.

5.2.6.4 GAUSS

This subroutine calculates the probability for a Gaussian distribution between two limits, XINIT and XFINL. This is the same routine that is contained in ROUTEMAP.

5.2.6.5 LATATN

This subroutine calculates the lateral attenuation using the algorithm developed by Speakman and Berry (Reference 2). This is the same routine that is contained in ROUTEMAP. In its present form, MRNMAP does not use this subroutine.

5.2.6.6 LINSEG

This subroutine calculates the value for the noise exposure integral which is described in Reference 3. The subroutine returns, through a variable called EXPOSE, a value between 0 and 1. MRNMAP calculates the noise for a finite line segment by multiplying EXPOSE with the pressure squared for an infinite line source. This is the same routine that is contained in NOISEMAP 6.0 with the exception that the power and speed interpolation made along a line segment have been disabled.

5.2.6.7 LMAXTRK

This subroutine calculates the maximum noise level (L_{max}) for a line segment. The line segment can be a described in this routine as a Gaussian distribution of line sources in the horizontal plane, having different standard deviations and altitudes at either end of the segment. This routine is activated when the LMAX keyword is inserted into the input file.

5.2.6.8 LVL2PSQR

This subroutine converts the sound pressure level from OMEGA10R to pressure squared. The conversion is made because the NOISEMAP calculations use pressure squared.

5.2.6.9 NMAP

This subroutine calculates the noise levels under a line segment and is the main calling routine for calculations involving a single predominate track. The subroutine uses the same algorithms as found in NOISEMAP.

5.2.6.10 RATADJ

This subroutine calculates the ONSET correction factor. The formula contained in this subroutine is described in Reference 10. The routine is called whenever the input file specifies a rate adjustment correction. This is the same algorithm that is found in ROUTEMAP.

5.2.6.11 RTCAL

This subroutine builds a look-up table of SEL versus the distance in the horizontal direction measured from the track centerline. This routine is used to model operations under an MTR. Input to the routine is the number of operations, the standard deviation of the route, and the effective acoustical altitude. The subroutine uses the same algorithms as found in ROUTEMAP.

5.2.6.12 RTMAP

This subroutine calculates the noise levels under a military training route. It is the main calling routine when the standard deviation and the altitude are the same at either end of a line segment. The algorithms contained in this subroutine are a combination of the algorithms found in NOISEMAP and ROUTEMAP.

5.2.6.13 SPREAD

This subroutine calculates the noise under a line segment where the operations are described as tracks that are distributed as a Gaussian distribution of line segments having a standard deviation and altitude that are not the same at either end of the line segment. This subroutine is the main calling routine. The algorithms contained in this subroutine are a blend of NOISEMAP and ROUTEMAP algorithms.

5.2.6.14 TURNSEG

This routine subdivides a turn into equal line segments and returns the grid point coordinates for these line segments. The subroutine assumes the turn is preceded by a straight line segment. The coordinates for the center of the turn are located along a line perpendicular to the line segment that precedes the turn.

5.3 Compiling and Linking MRNMAP

Compiling and linking the source code requires Microsoft FORTRAN Version 5.1. Included on the distribution disk are two batch files called MDOS.BAT and MWIN.BAT. File MDOS is used to compile and link MRNMAP under DOS; and MWIN is used to compile and link MRNMAP under Microsoft Windows.

MRNMAP makes occasional use of Microsoft QuickWin Application tools and the Microsoft C functions. These program statements are used when MRNMAP is compiled under Windows or Windows NT. When the functions are not in use under DOS they appear in the source code as commented statements. Compiling and linking the source code to produce an executable code to run under Windows or Windows NT requires removing the "C" from column 1 to activate these program statements. These commented statements are found in the main program, MRNMAP, and in subroutine INPUT.

The Microsoft FORTRAN QuickWin library does not contain the C functions GETENV and STRNCMP. These libraries are, however, contained in the Microsoft FORTRAN library LLIBFOR7. Before compiling MRNMAP under Microsoft Windows, use the following commands at the DOS prompt to modify your Microsoft FORTRAN Windows library.

```
LIB LLIBFOR7 *GETENV *STRNCMP
LIB LLIBFEW +GETENV +STRNCMP
```

Under DOS the size of the grid domain is limited to 10,000 grid points. When MRNMAP is run under Microsoft Windows, it can access extended memory and memory paging features available only under Microsoft Windows and Windows NT. To increase the grid size beyond 10,000 points, change the value of ITOT in subroutine GRID to the desired number of grid points and recompile MRNMAP to run under Windows.

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9. Frampton, K.D., Lucas, M.J., Plotkin, K.J., "Assessment of the Subsonic Noise Environment in the Nellis Range Complex", Wyle Research Report WR 93-3, January 1993.

10. Stusnick, E., *et al.*, "The Effect of Onset Rate on Aircraft Noise Annoyance. Vol. 3: Hybrid Own-Home Experiment", Wyle Research Report WR 93-22, December 1993.

APPENDIX A

Nellis Range Altitude Histograms

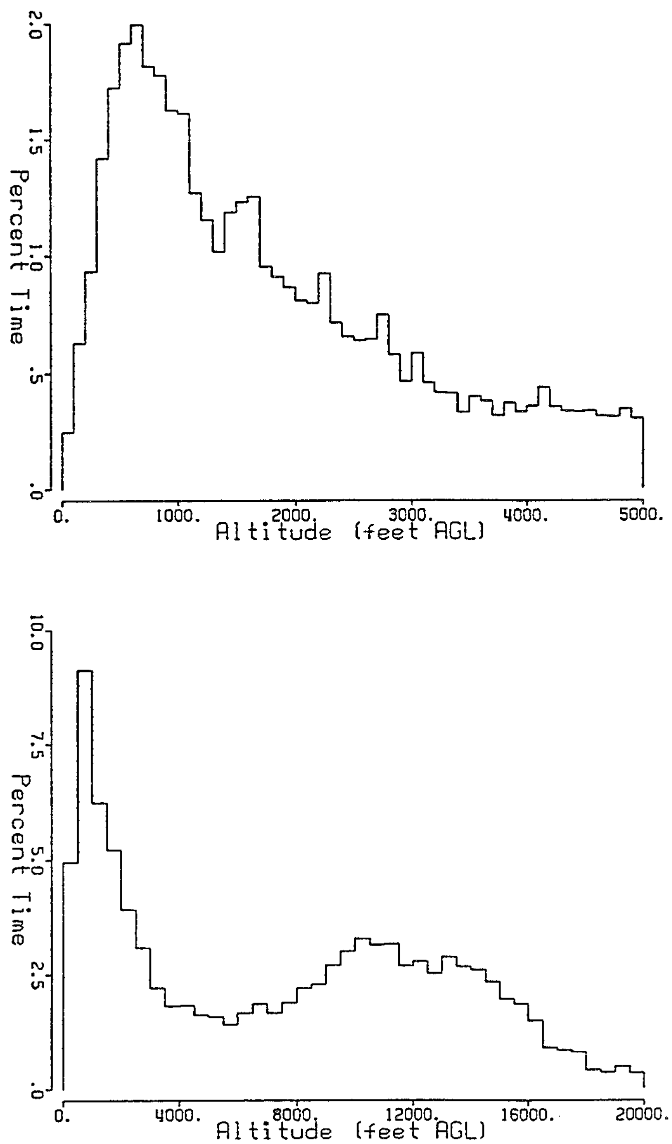


Figure A-1. A-10 Close Air Support Mission Altitude Histogram.

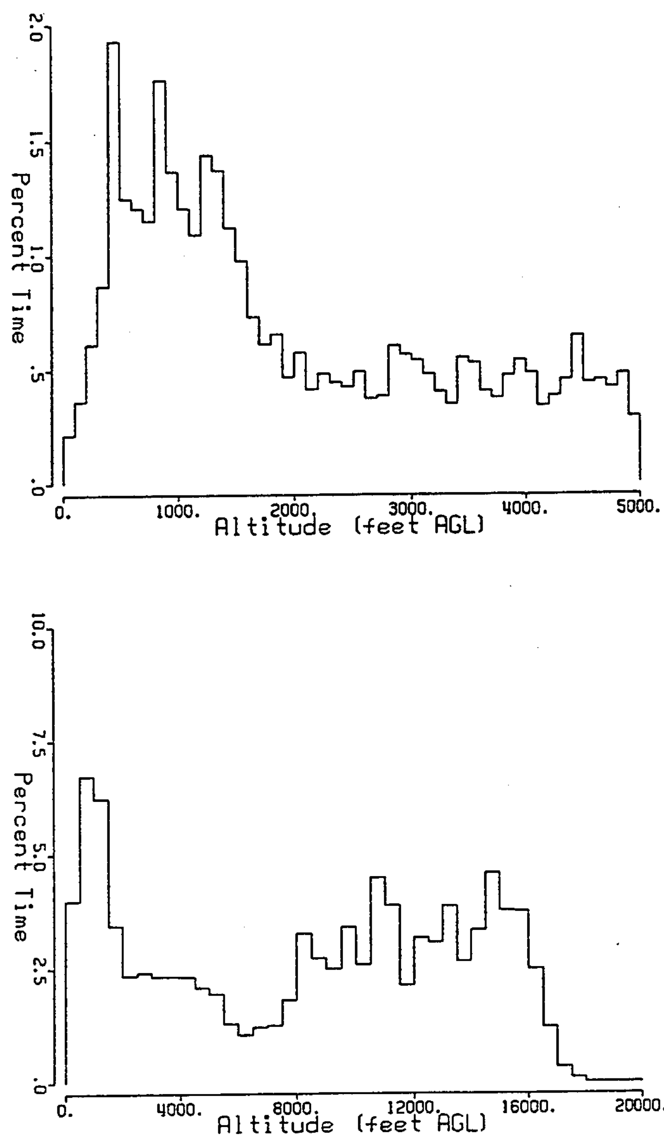


Figure A-2. A-10 Escort Mission Altitude Histogram.

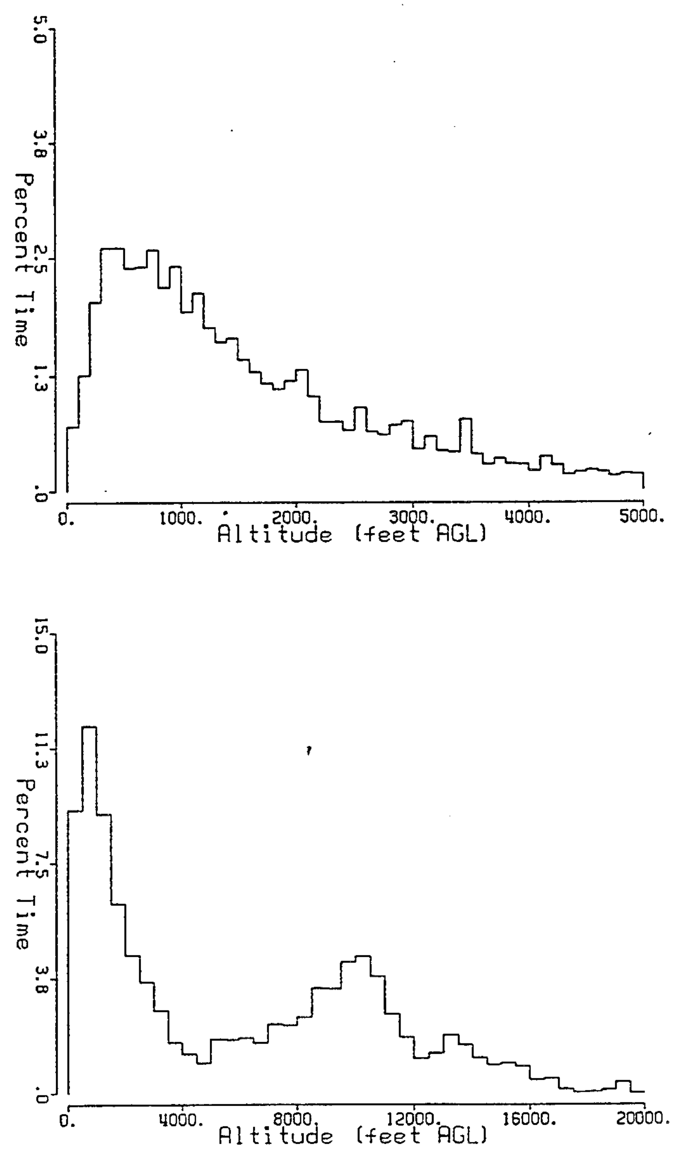


Figure A-3. A-10 Forward Air Control Mission Altitude Histogram.

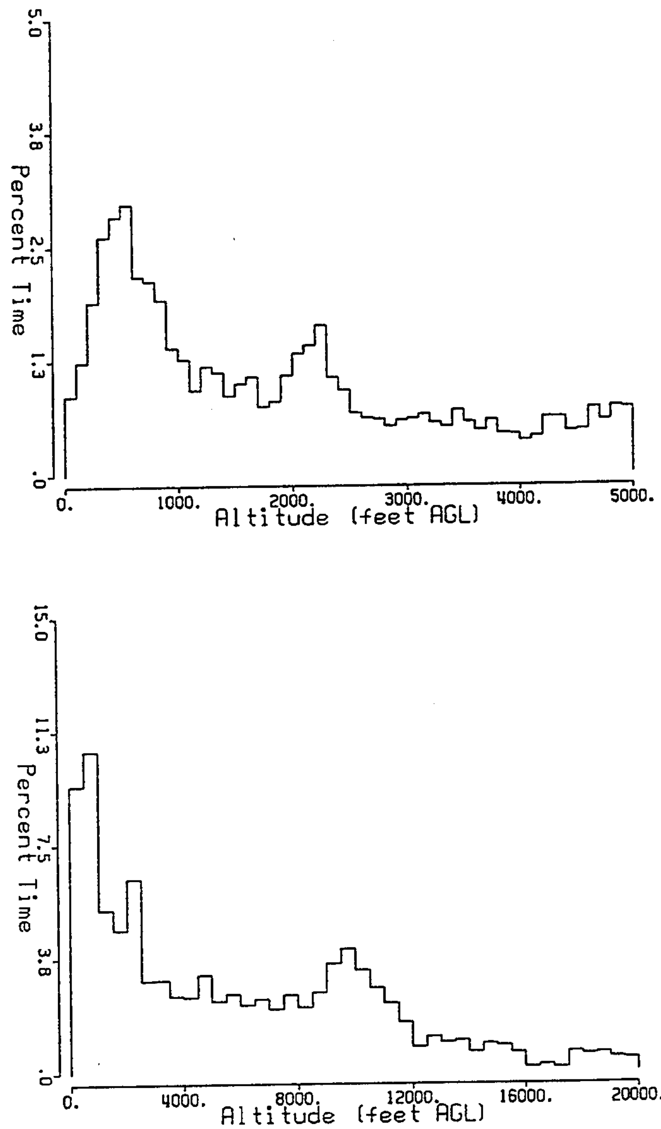


Figure A-4. A-10 Battlefield Air Interdiction Mission Altitude Histogram.

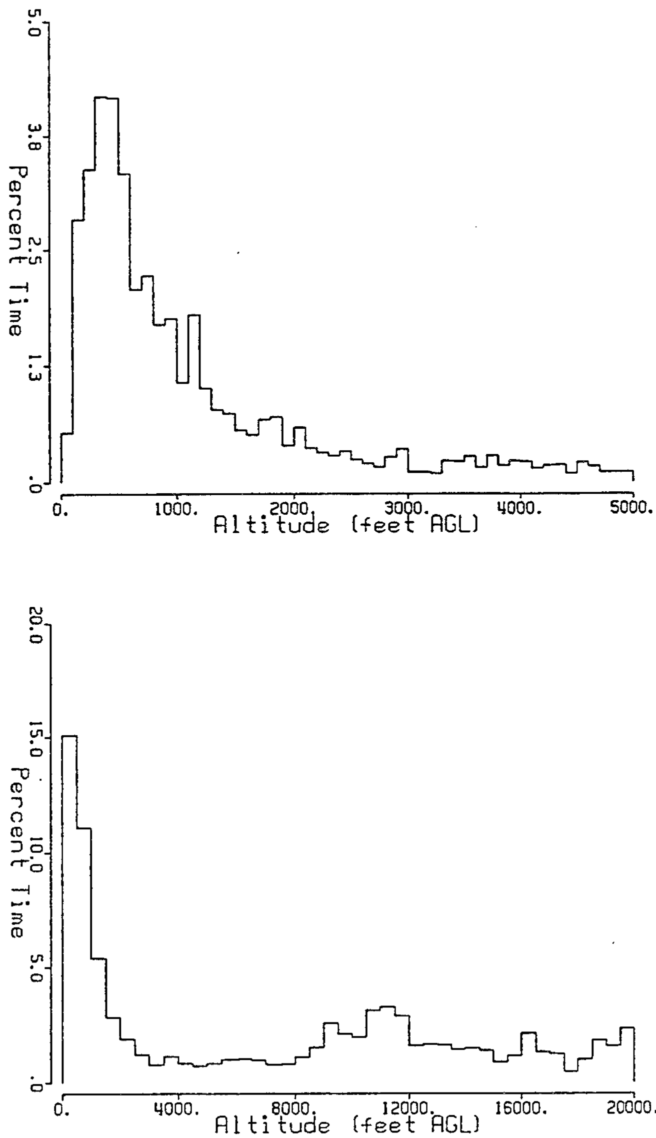


Figure A-5. A-10 Interdiction Mission Altitude Histogram.

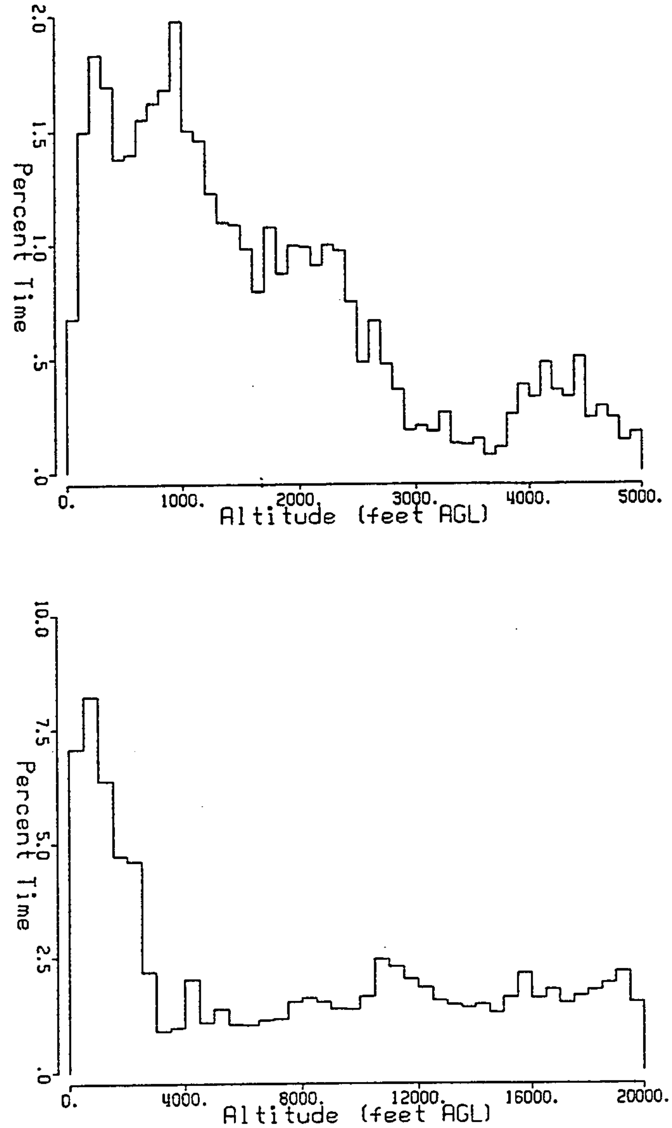


Figure A-6. B-52 Interdiction Mission Altitude Histogram.

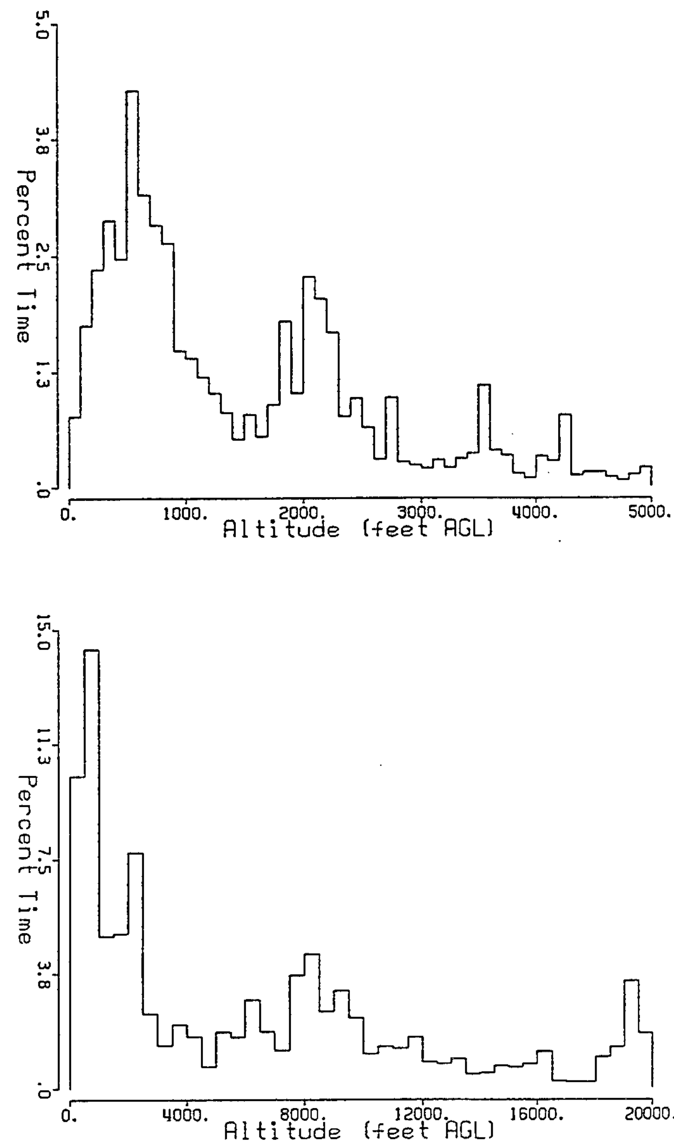


Figure A-7. B-52 Offensive Counter Air Mission Altitude Histogram.

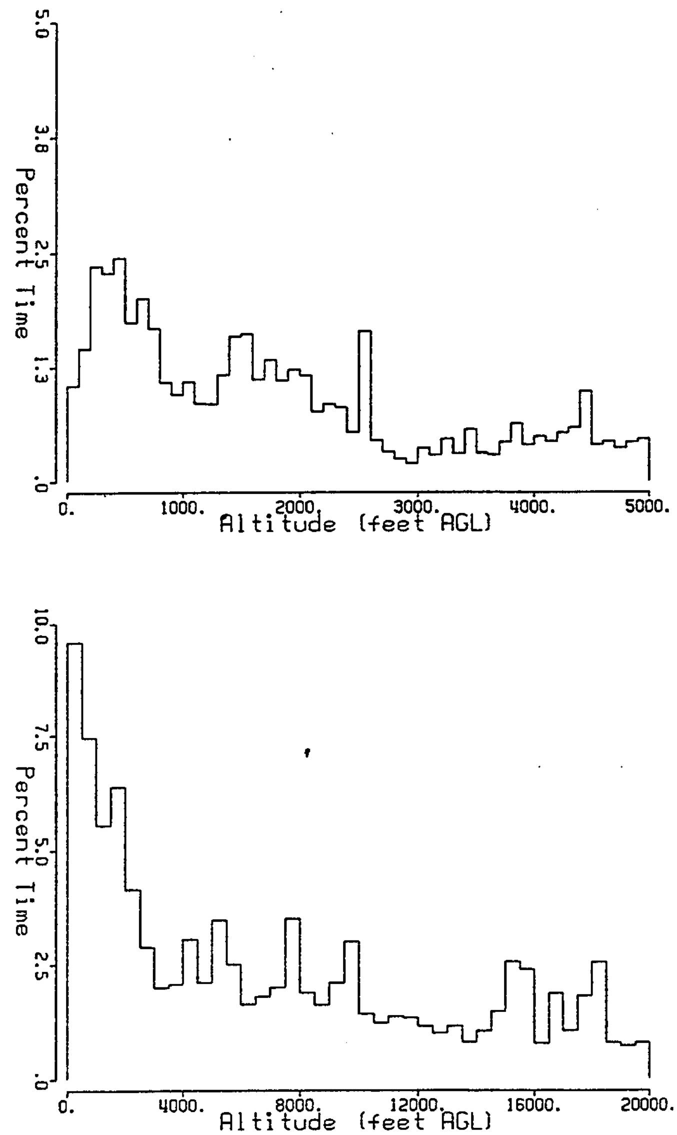


Figure A-8. C-130 Tactical Air Drop Mission Altitude Histogram.

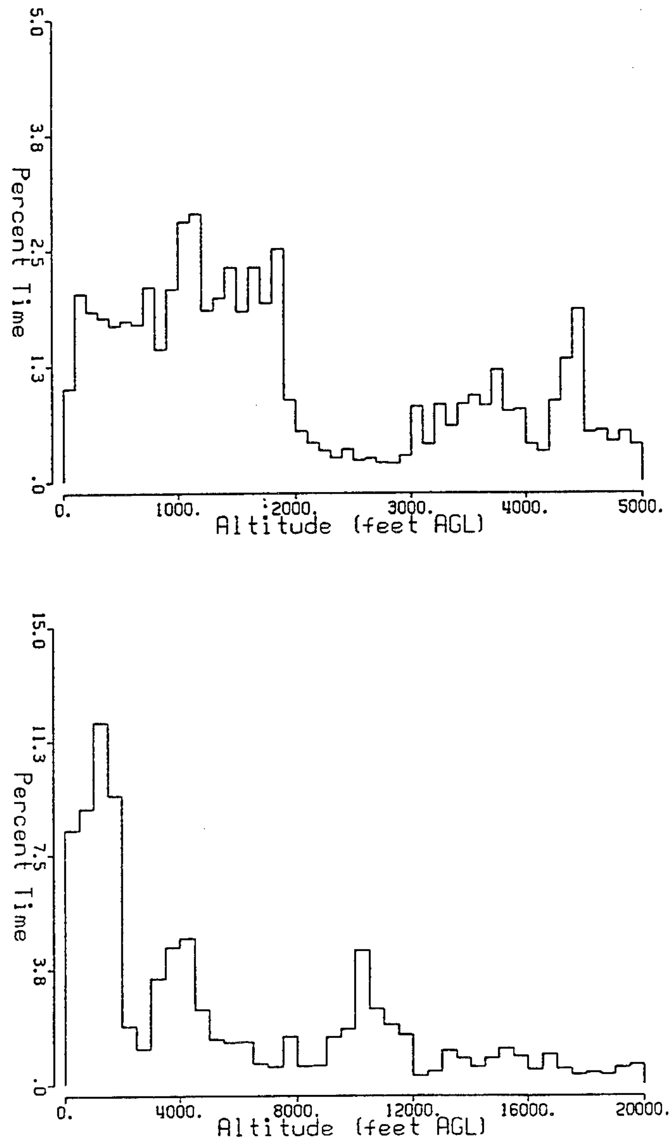


Figure A-9. E-6B Electronic Warfare Mission Altitude Histogram.

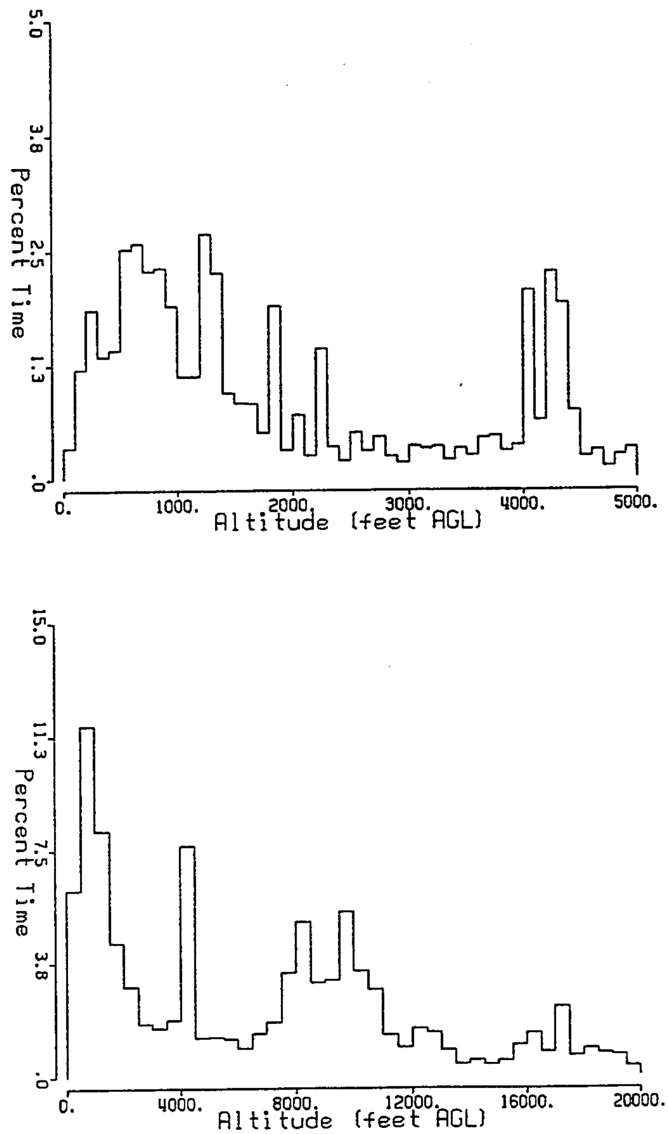


Figure A-10. E-6B Suppression of Energy Air Defense Mission Altitude Histogram.

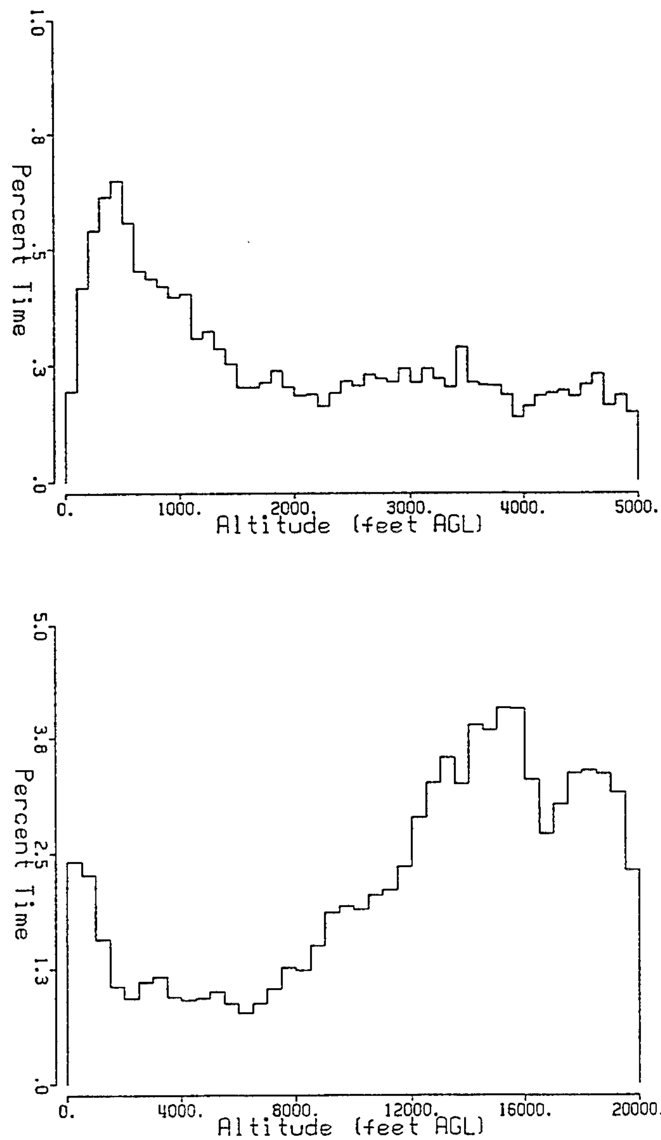
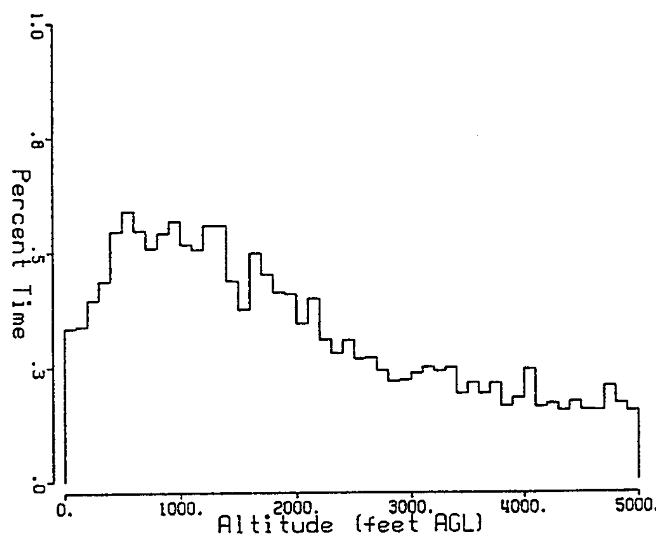


Figure A-11. F-14 Defensive Counter Air Mission Altitude Histogram.



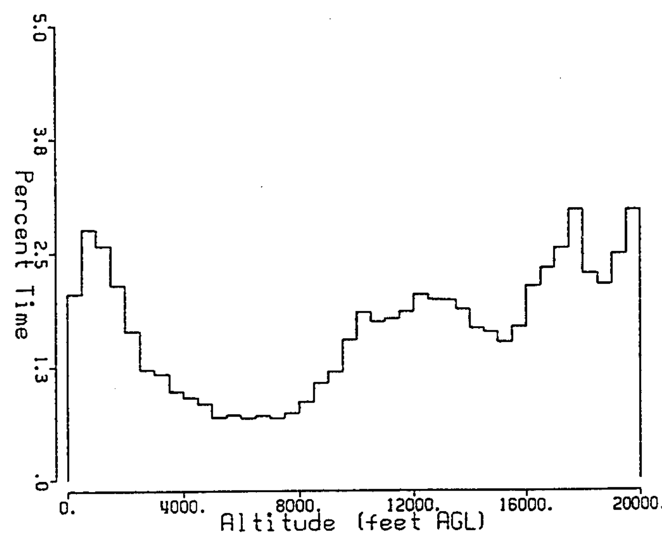


Figure A-12. F-15 Escort Mission Altitude Histogram.

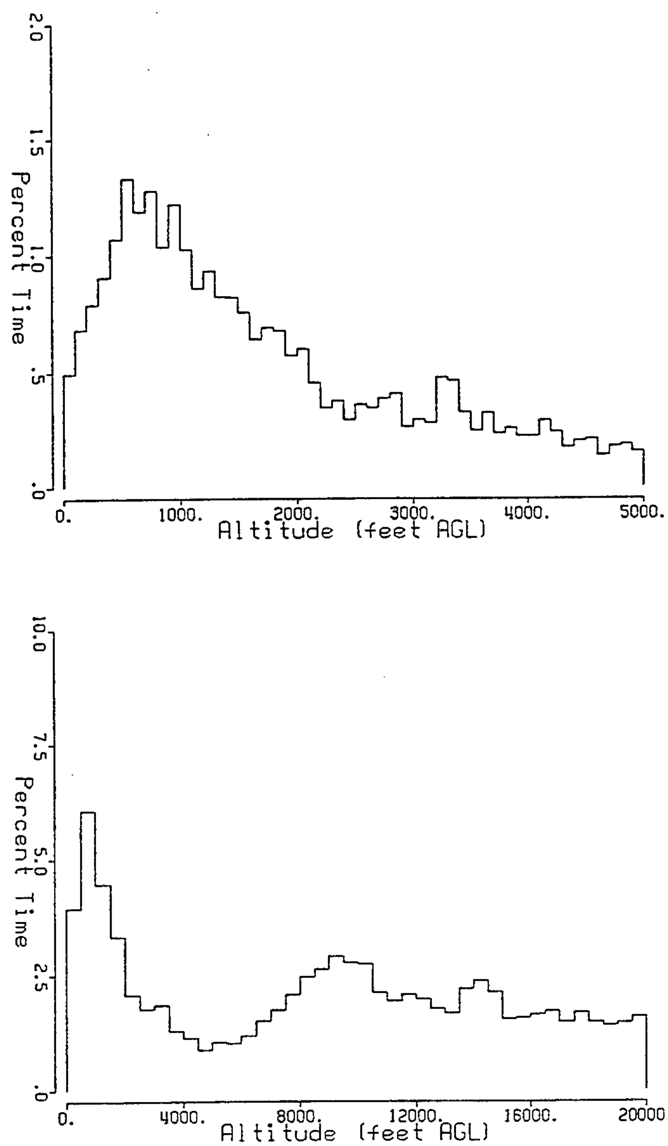


Figure A-13. F-15 Interdiction Mission Altitude Histogram.

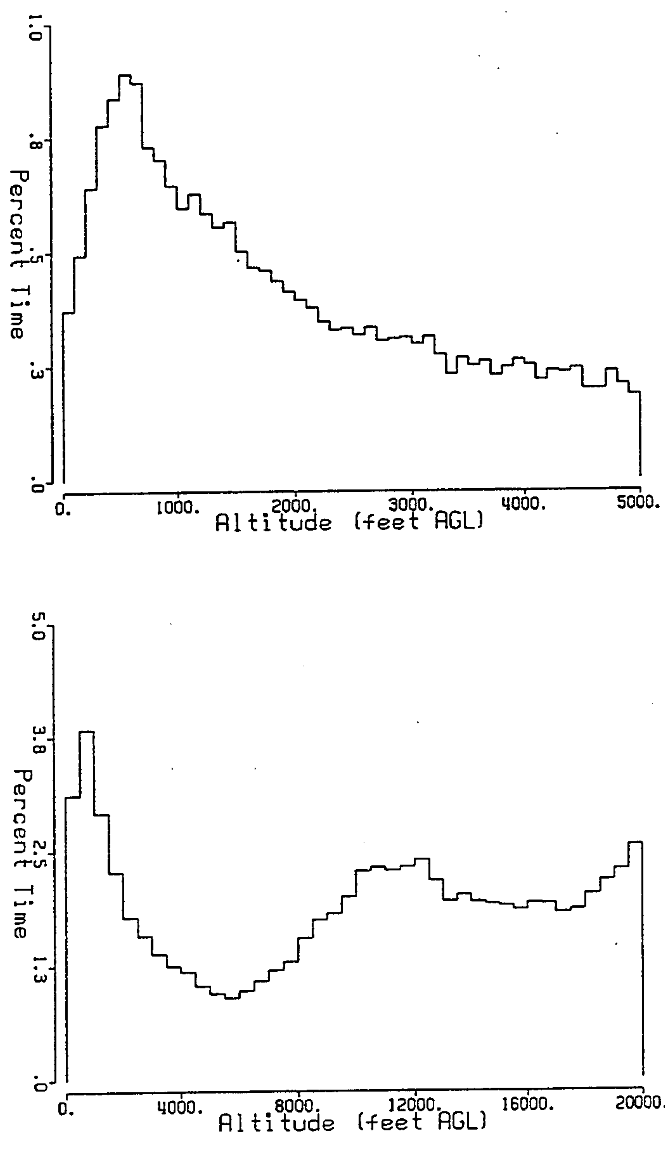
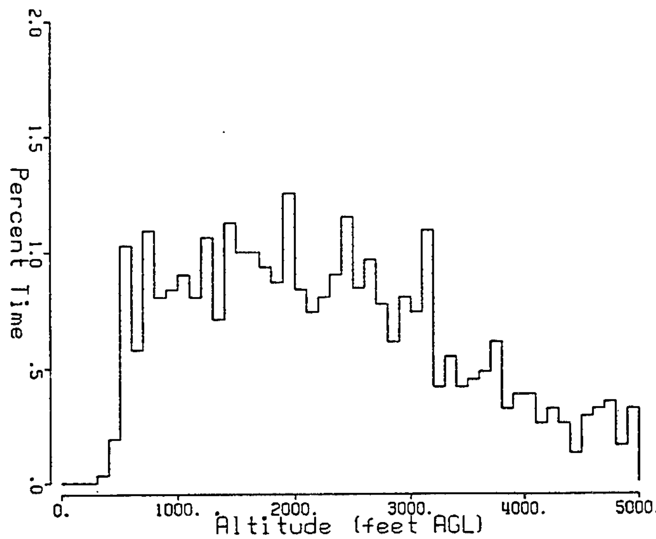


Figure A-14. F-15 Offensive Counter Air Mission Altitude Histogram.



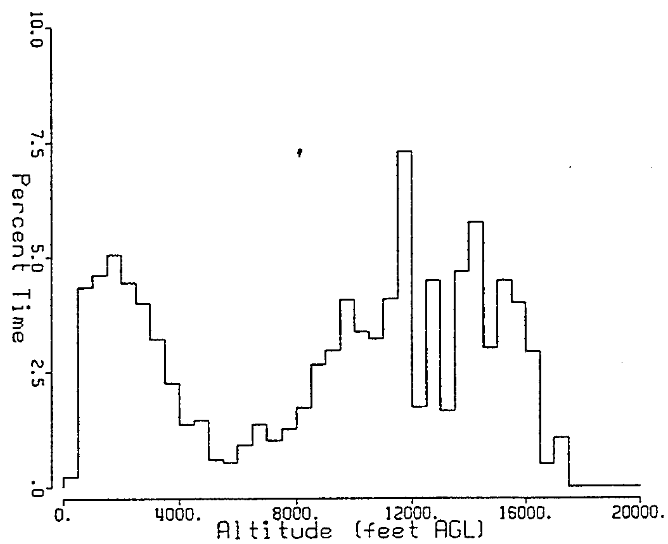


Figure A-15. F-15 All Other Missions Altitude Histogram.

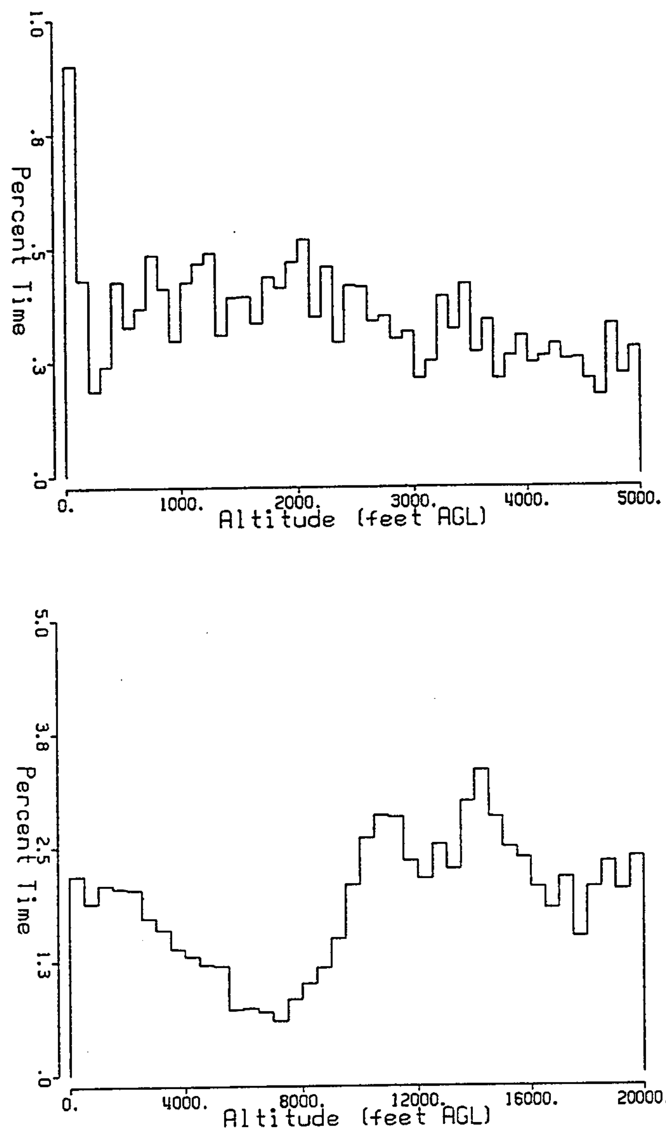


Figure A-16. F-16 Close Air Support Mission Altitude Histogram.

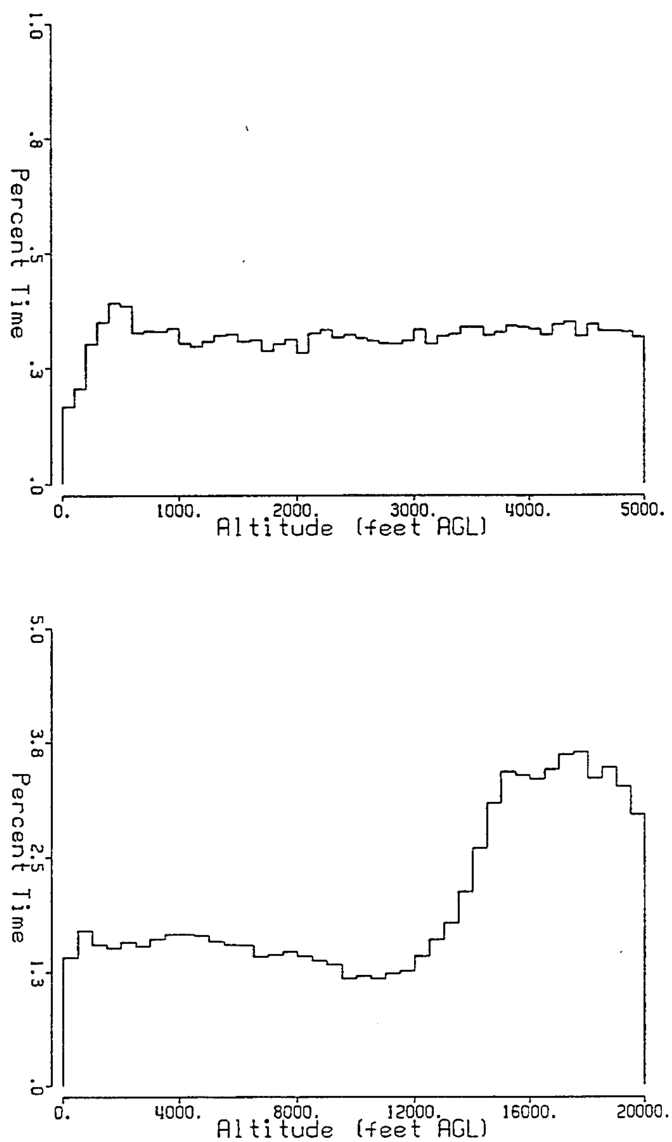
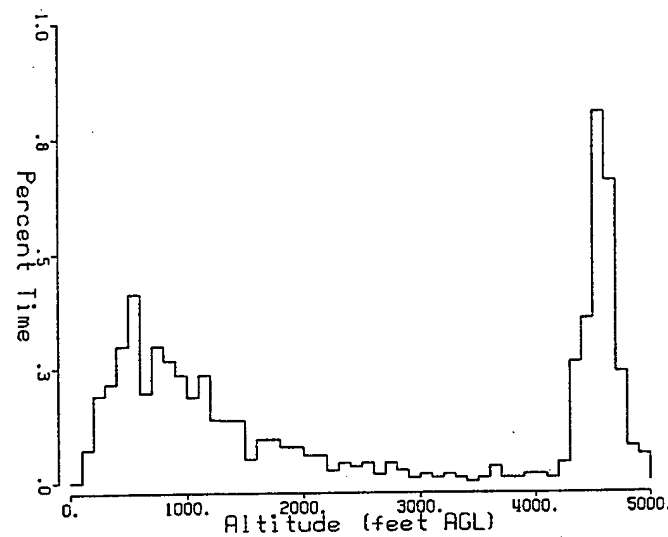


Figure A-17. F-16 Defensive Counter Air Mission Altitude Histogram.



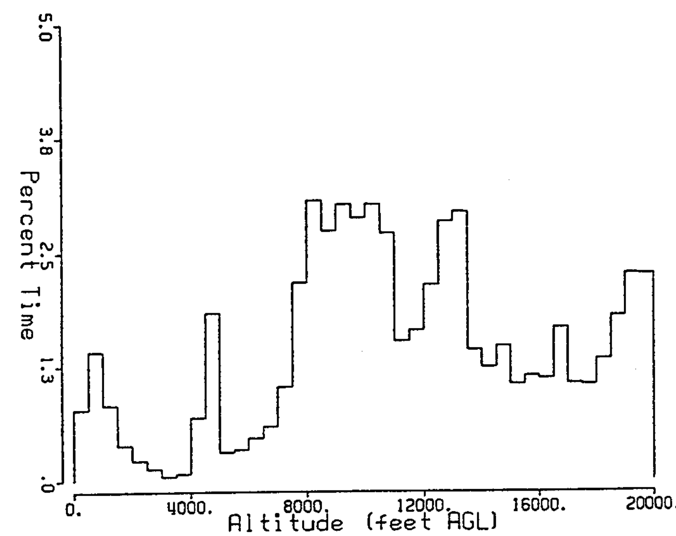


Figure A-18. F-16 Escort Mission Altitude Histogram.

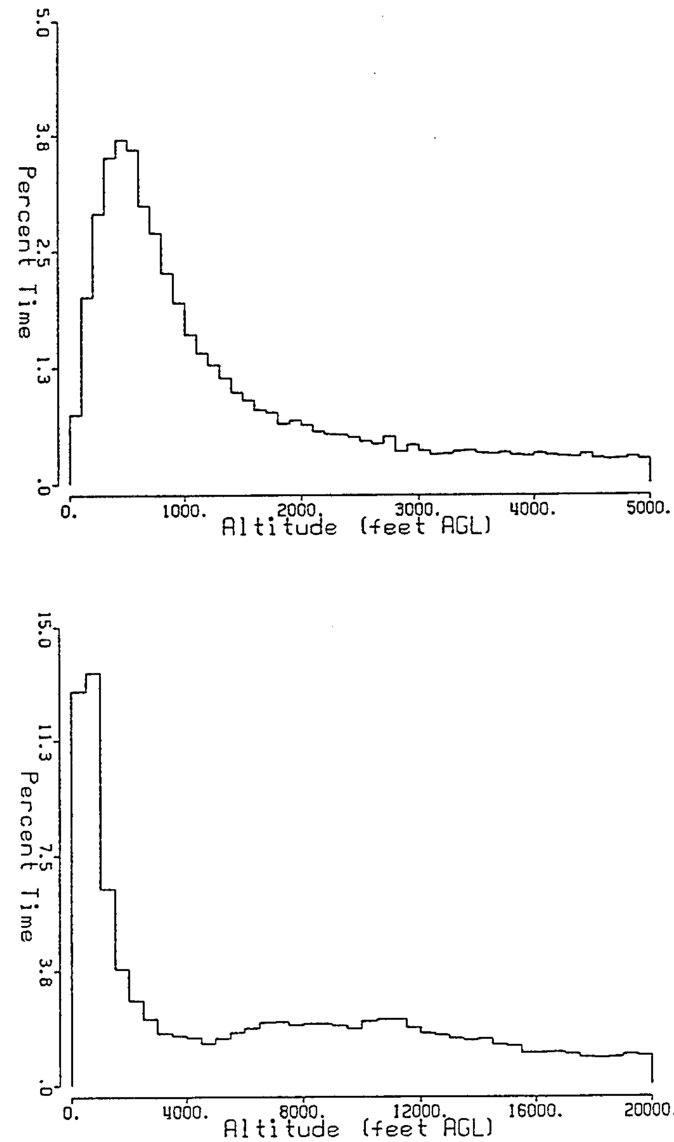


Figure A-19. F-16 Interdiction Mission Altitude Histogram.

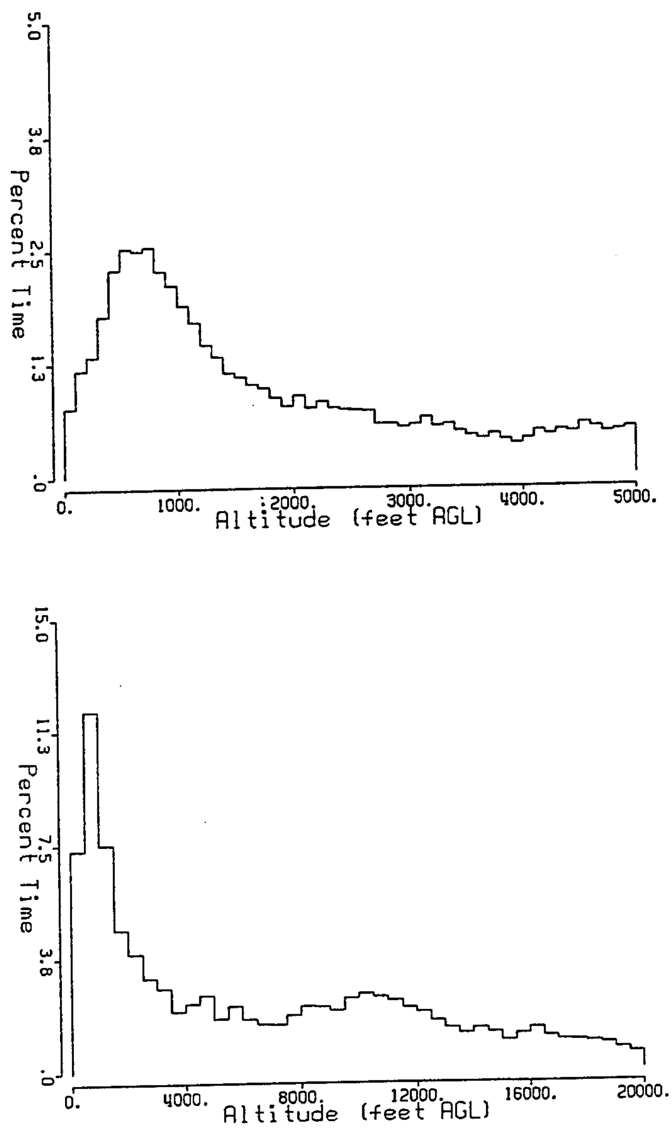


Figure A-20. F-16 Offensive Counter Air Mission Altitude Histogram.

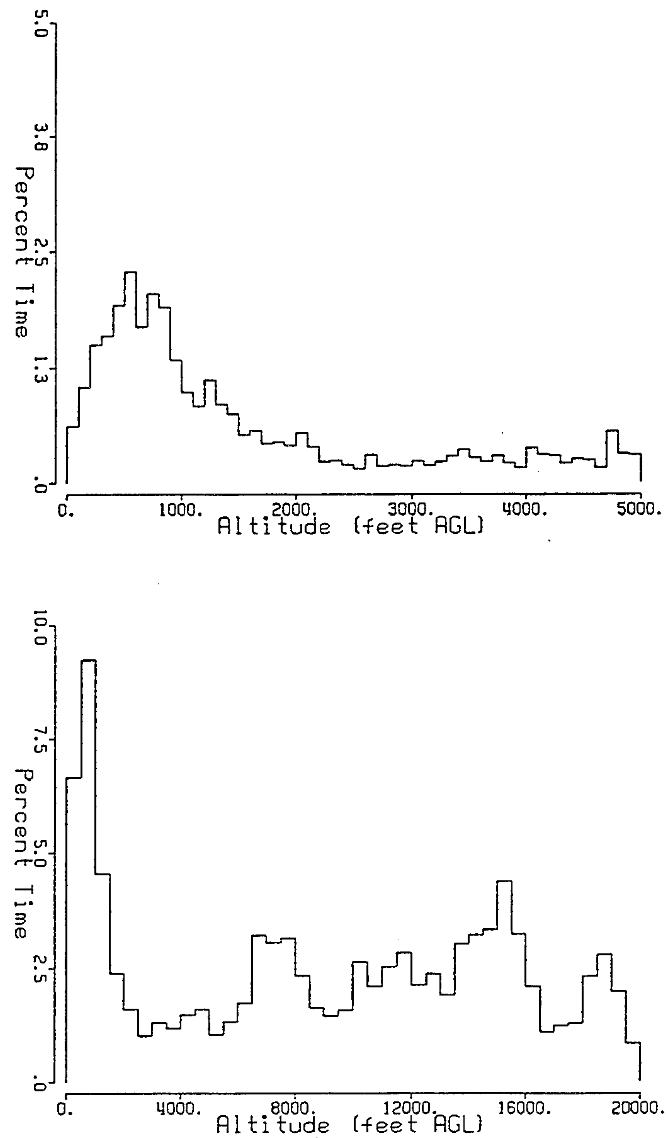


Figure A-21. F-16 All Other Missions Altitude Histogram.

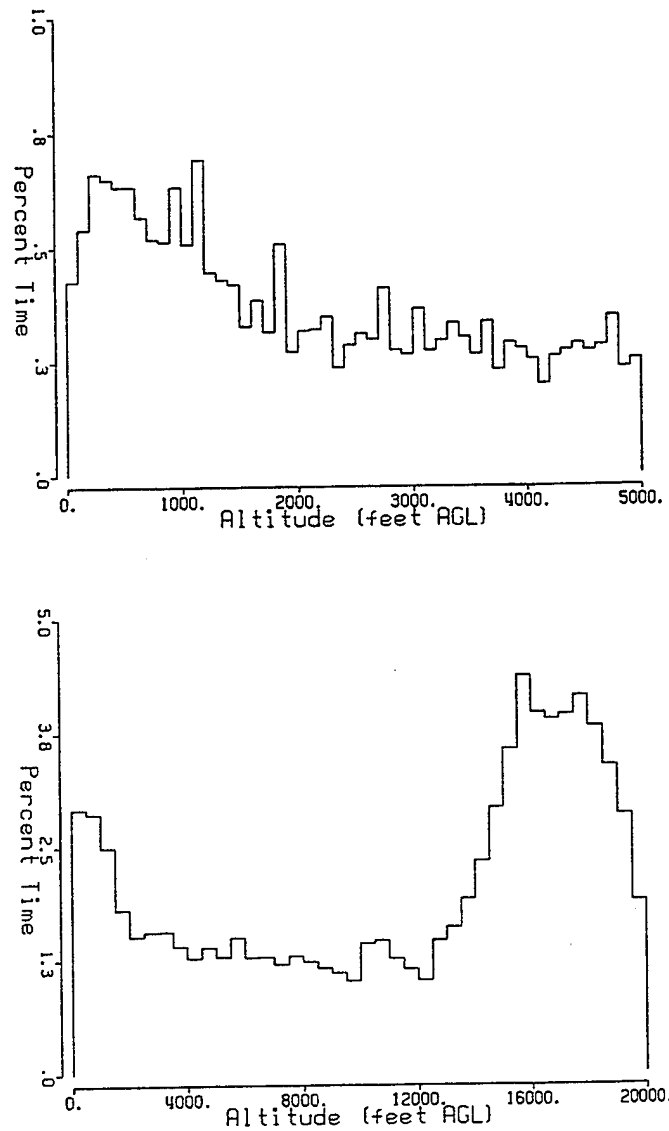


Figure A-22. F-18 Defensive Counter Air Mission Altitude Histogram.

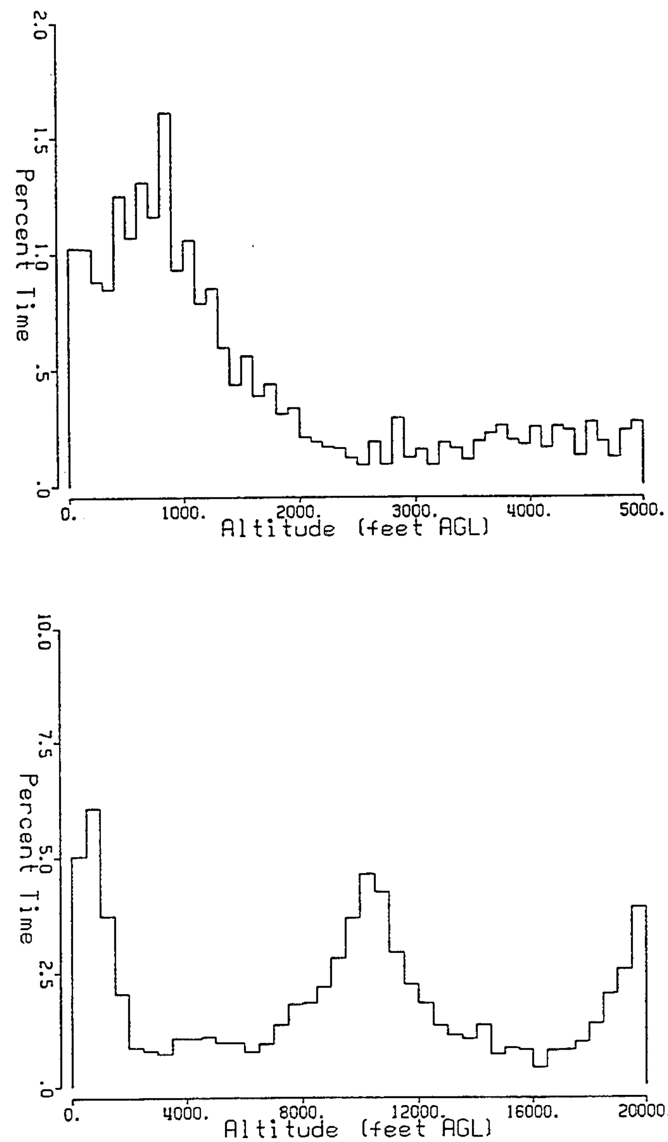


Figure A-23. F-18 Wild Weasel Mission Altitude Histogram.

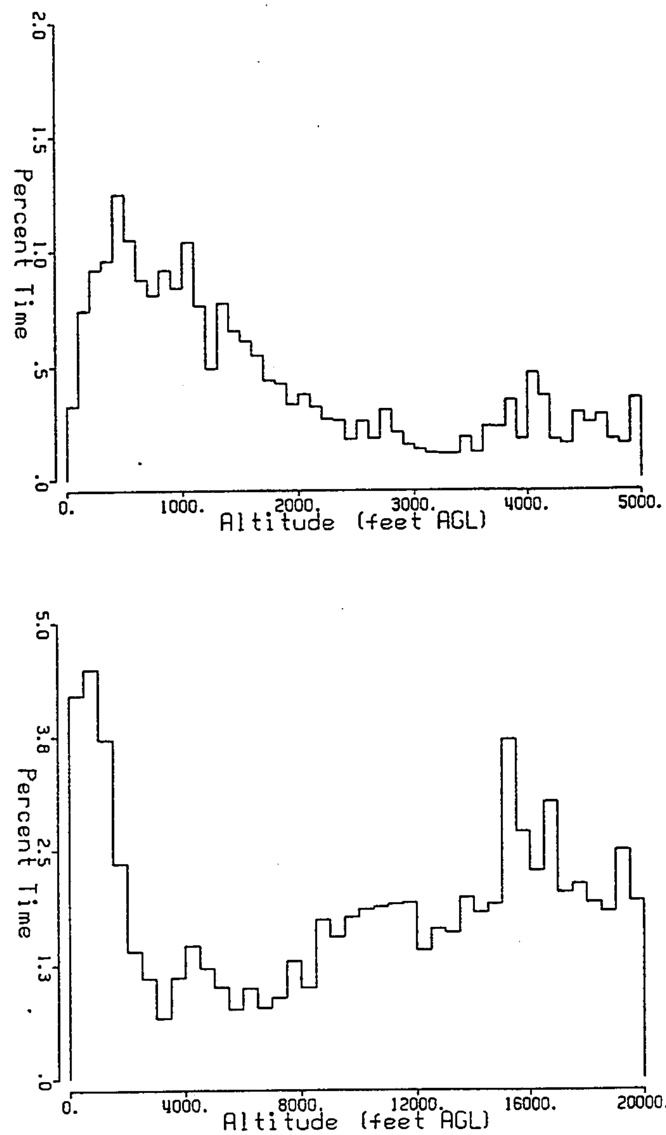
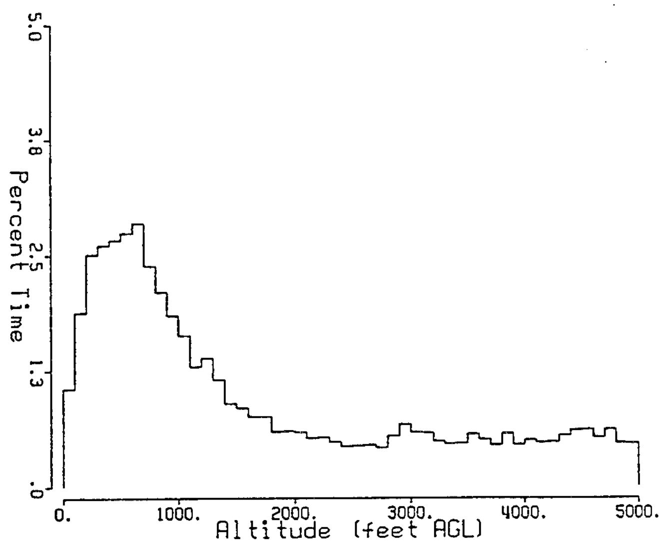


Figure A-24. F-111E Electronic Warfare Mission Altitude Histogram.



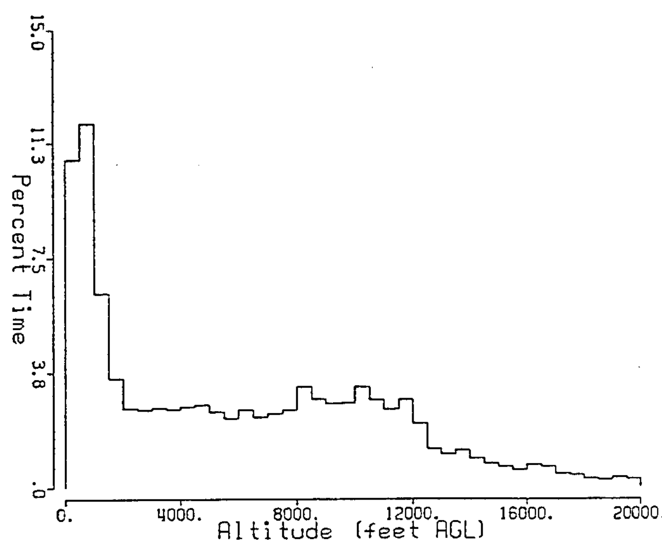


Figure A-25. F-111F Interdiction Mission Altitude Histogram.

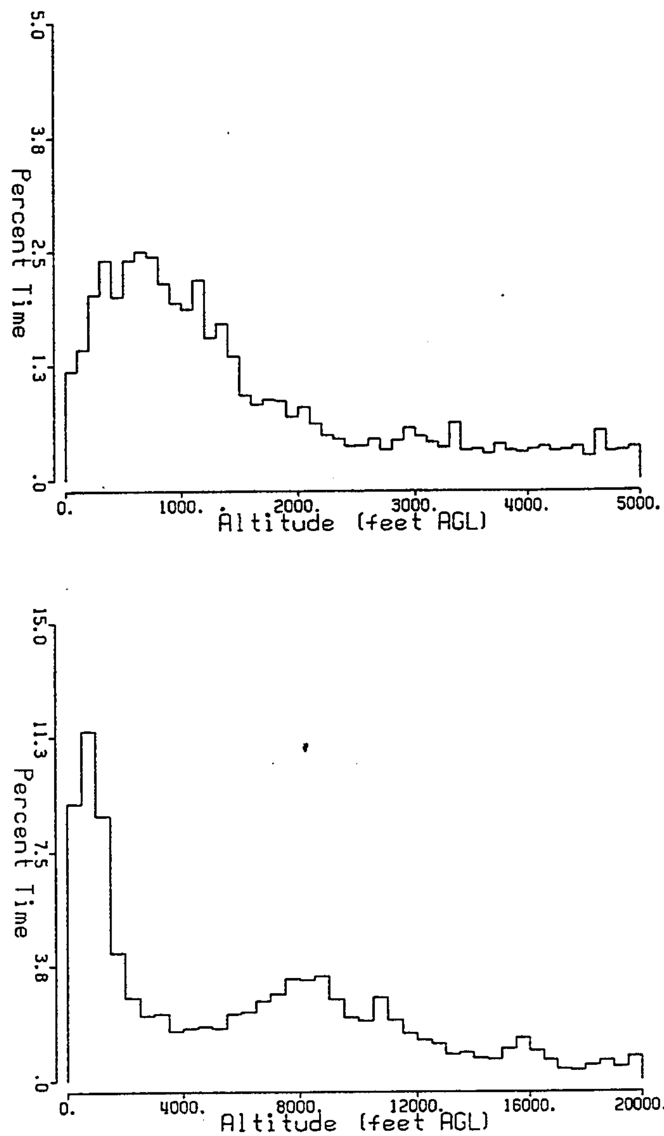


Figure A-26. F-111F Offensive Counter Air Mission Altitude Histogram.

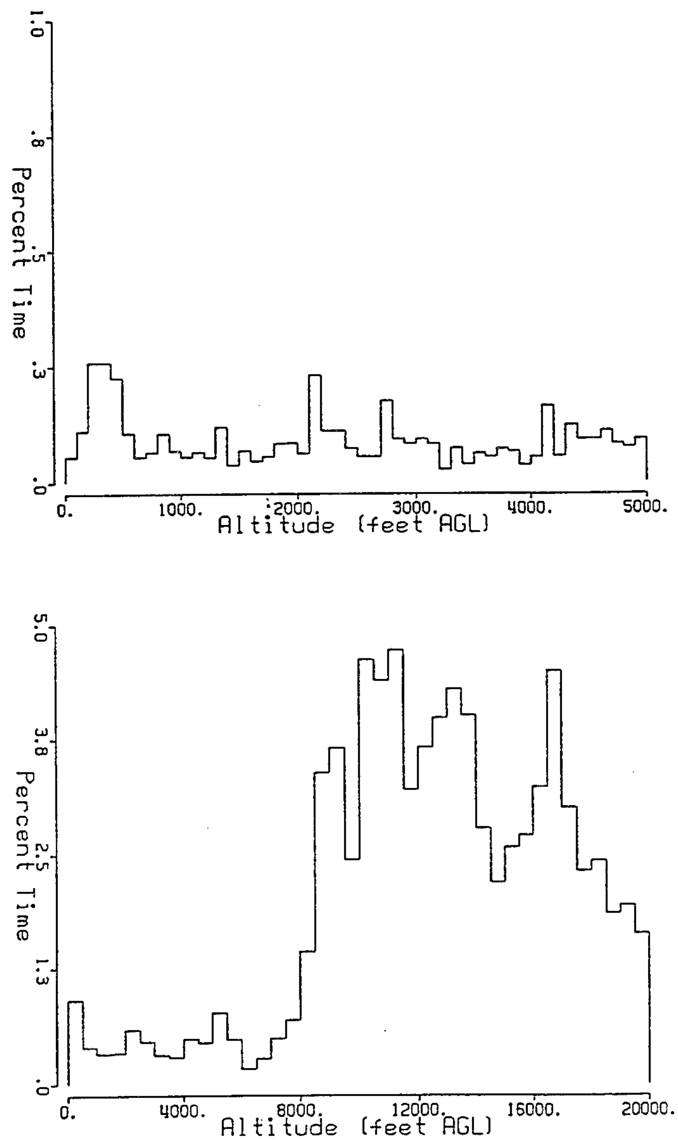


Figure A-27. Tornado Escort Mission Altitude Histogram.

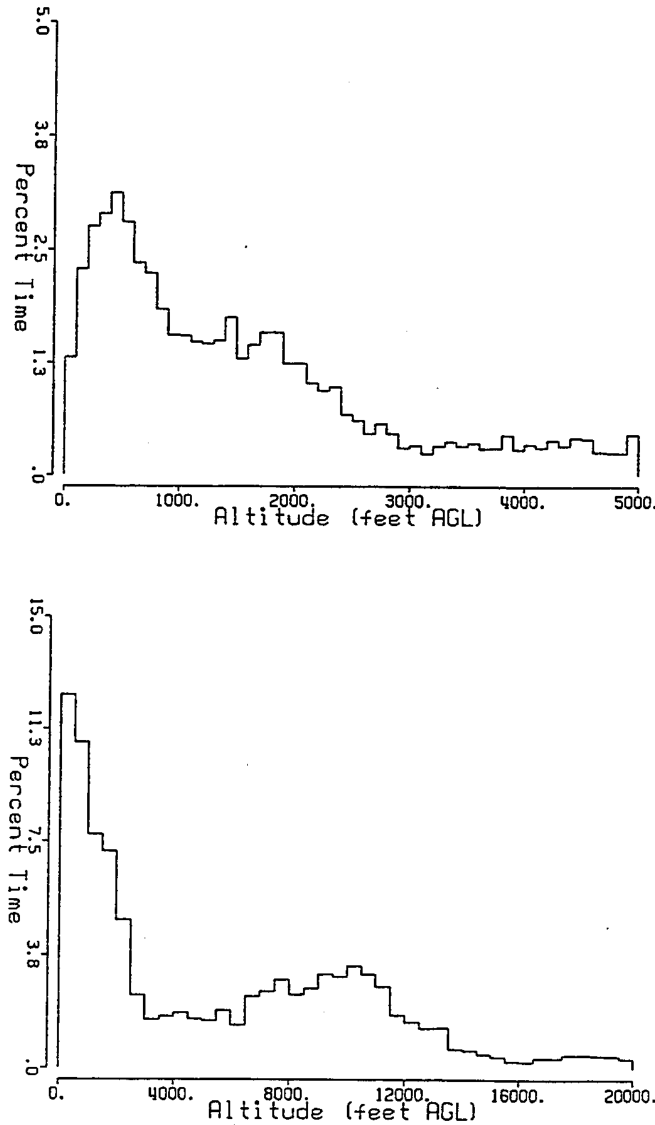


Figure A-28. Tornado Interdiction Mission Altitude Histogram.

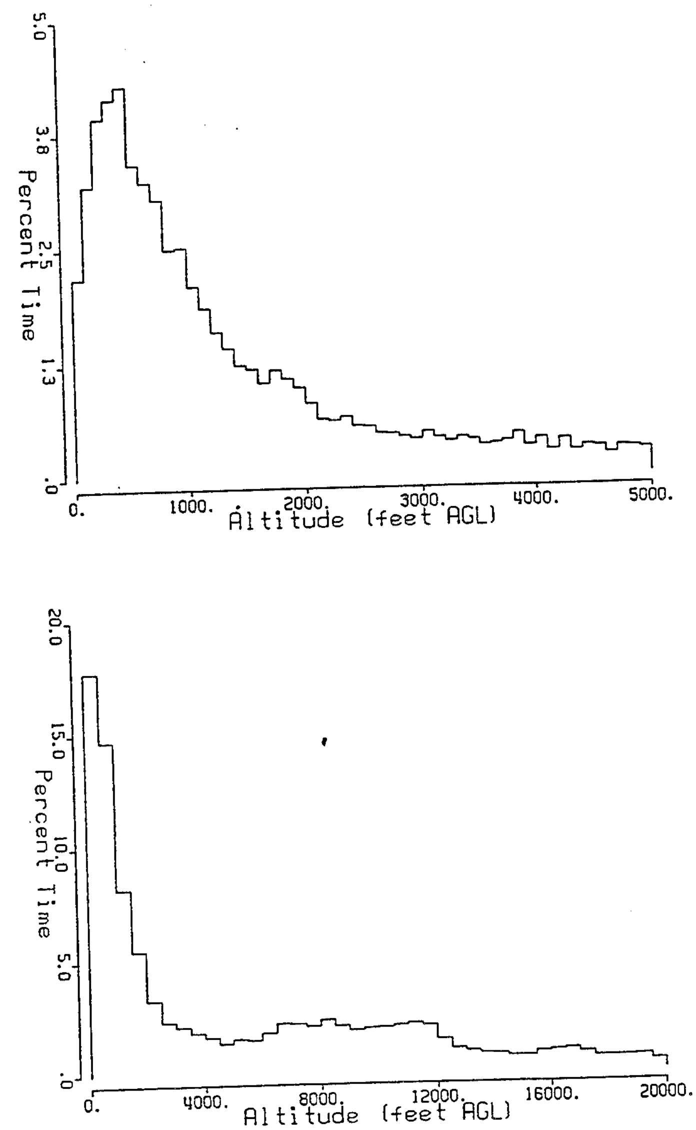
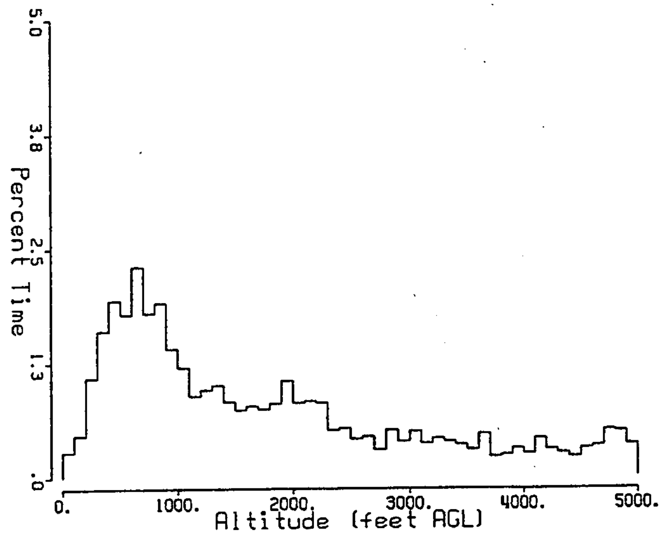


Figure A-29. Tornado Offensive Counter Air Mission Altitude Histogram.



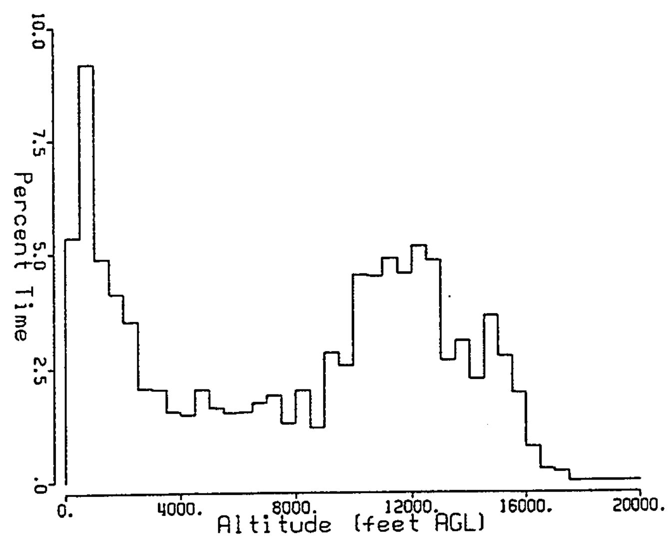


Figure A-30. Tornado All Other Missions Altitude Histogram.

APPENDIX B

Nellis Range Speed Histograms

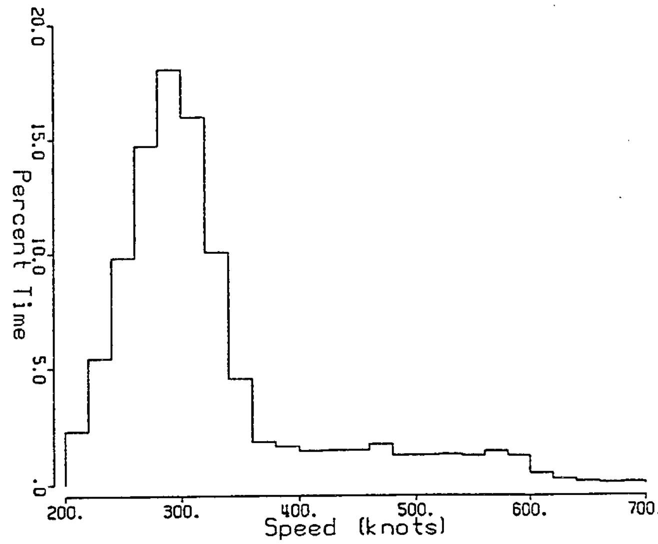


Figure B-1. A-10 Close Air Support Mission Speed Histogram.

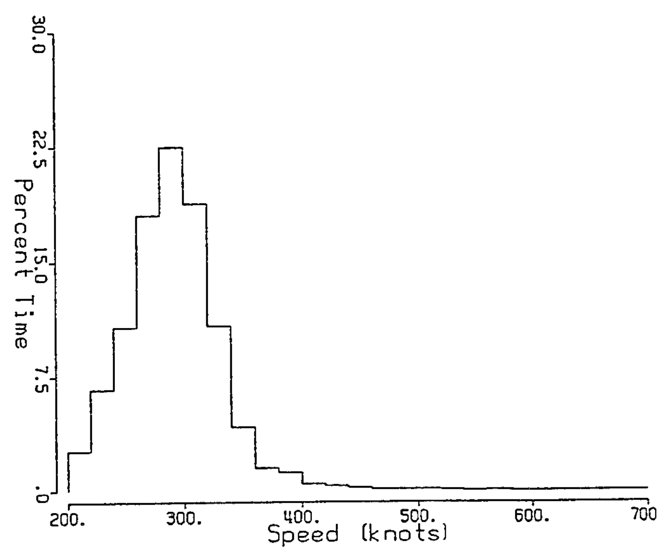


Figure B-2. A-10 Escort Mission Speed Histogram.

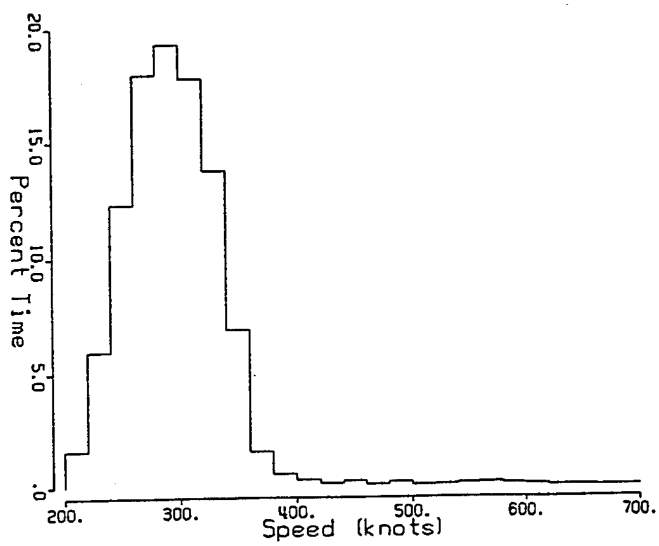


Figure B-3. A-10 Forward Air Control Mission Speed Histogram.

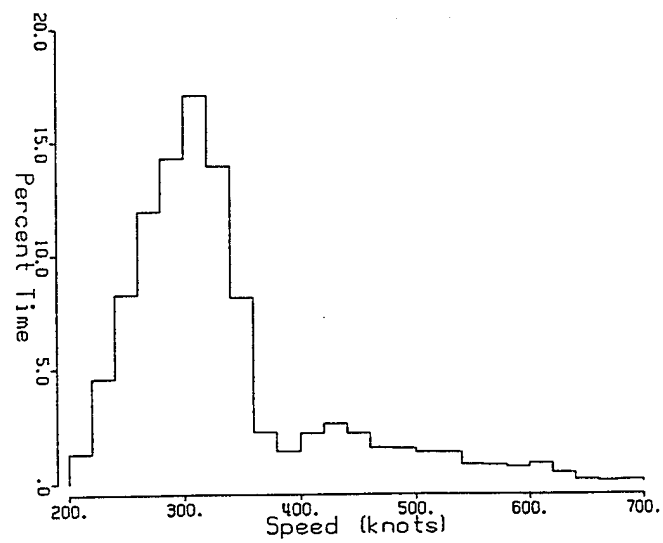


Figure B-4. A-10 Battlefield Air Interdiction Mission Speed Histogram.

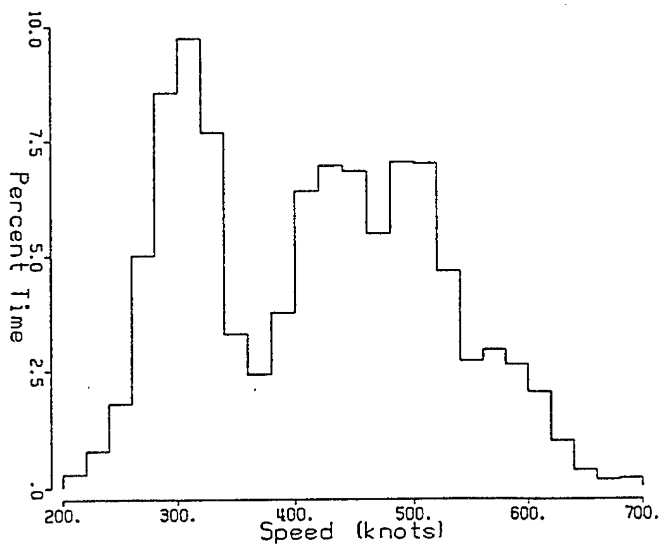


Figure B-5. A-10 Interdiction Mission Speed Histogram.

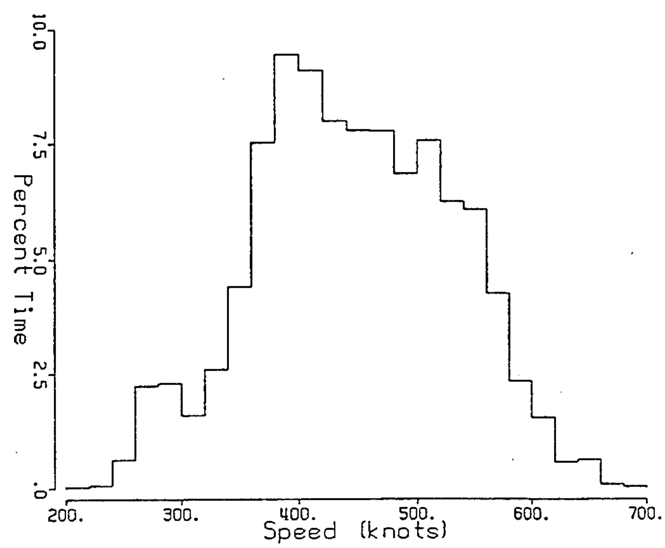


Figure B-6. B-52 Interdiction Mission Speed Histogram.

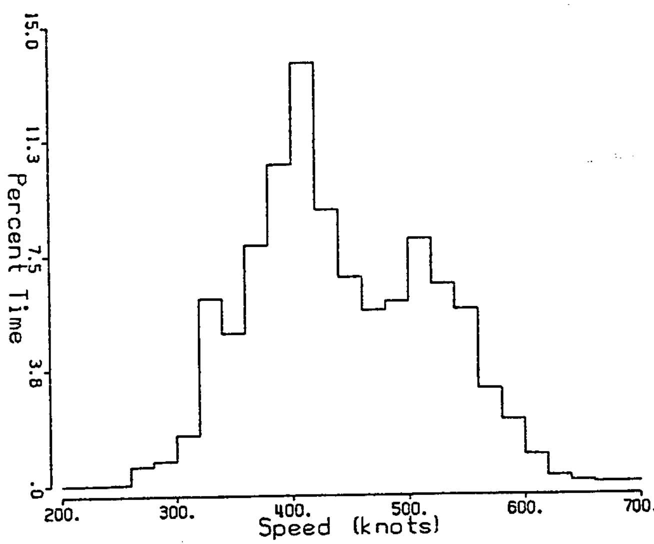


Figure B-7. B-52 Offensive Counter Air Mission Speed Histogram.

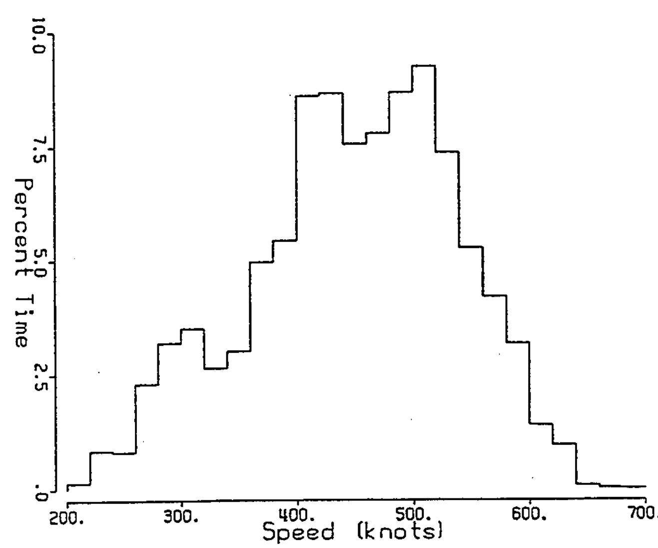


Figure B-8. C-130 Tactical Air Drop Mission Speed Histogram.

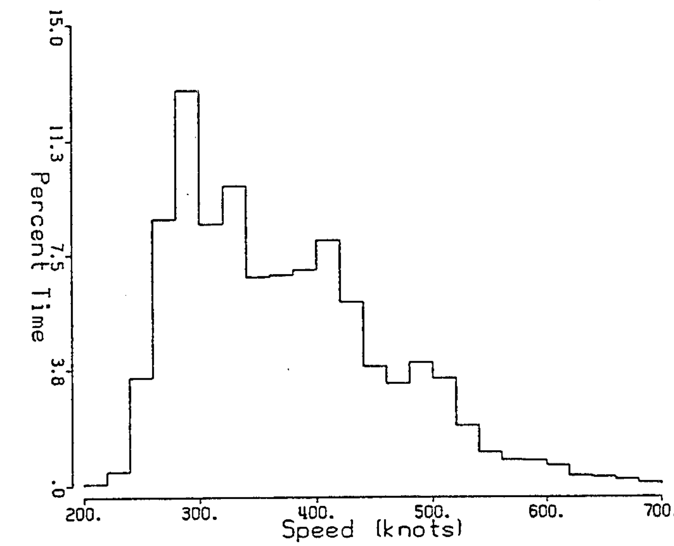


Figure B-9. E-6B Electronic Warfare Mission Speed Histogram.

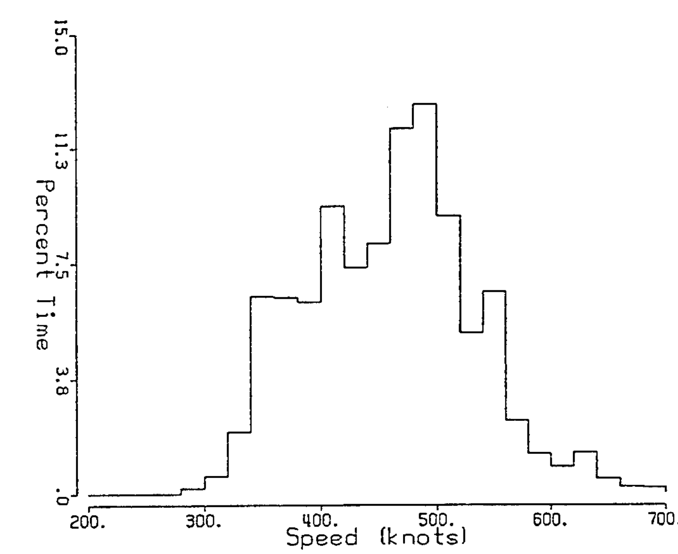


Figure B-10. E-6B Suppression of Energy Air Defense Mission Speed Histogram.

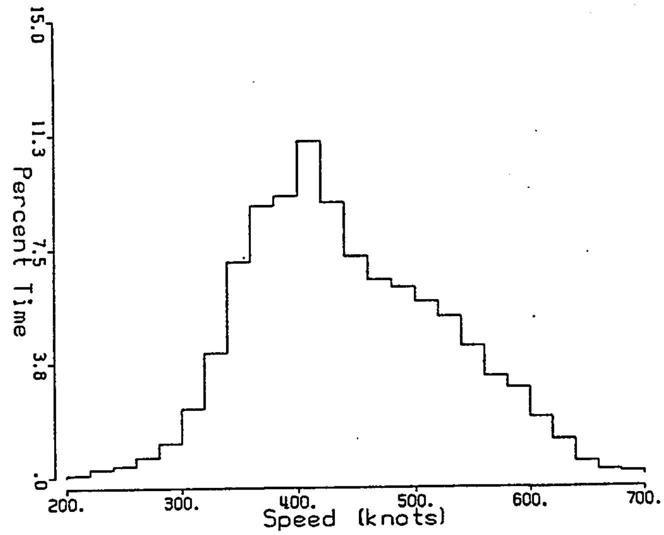


Figure B-11. F-14 Defensive Counter Air Mission Speed Histogram.

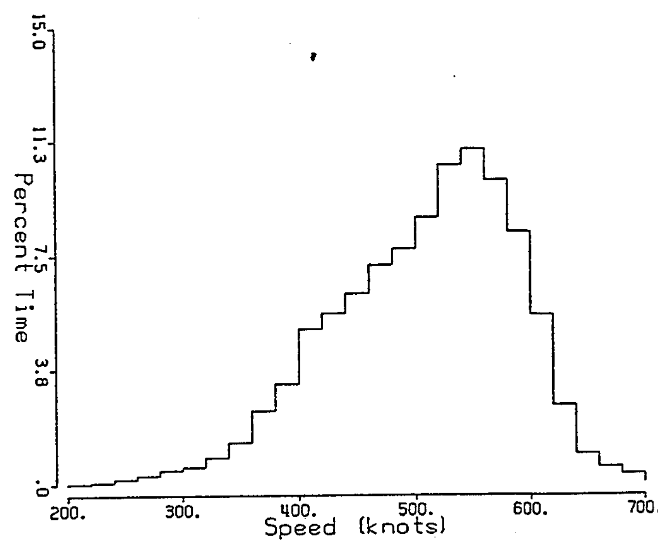


Figure B-12. F-15 Escort Mission Speed Histogram.

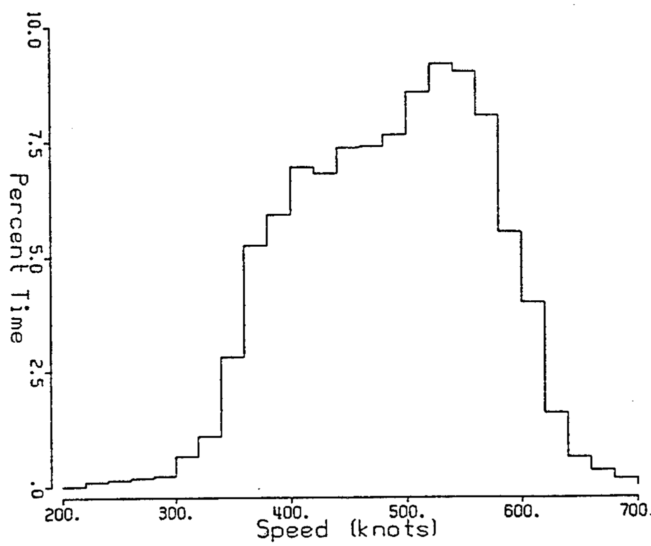


Figure B-13. F-15 Interdiction Mission Speed Histogram.

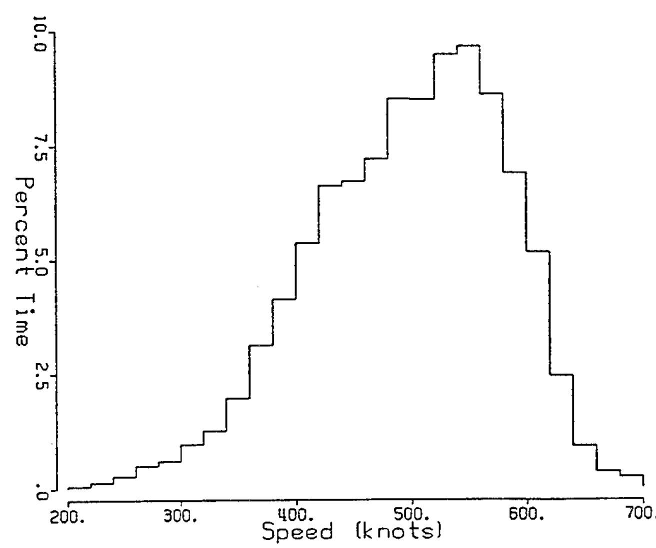


Figure B-14. F-15 Offensive Counter Air Mission Speed Histogram.

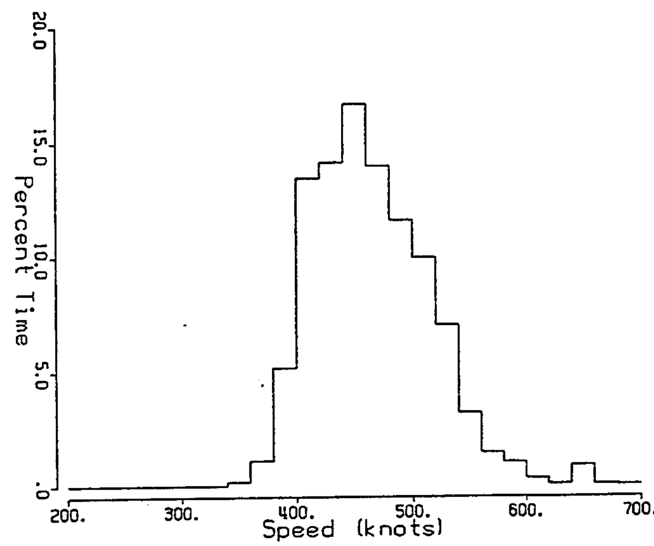


Figure B-15. F-15 All Other Missions Speed Histogram.

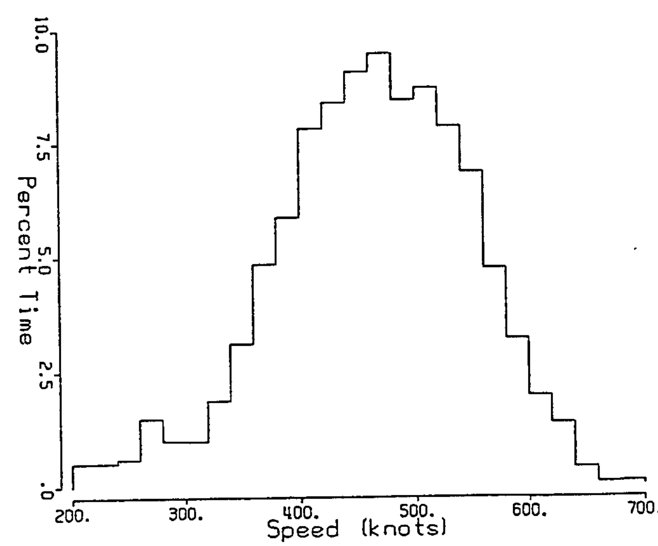


Figure B-16. F-16 Close Air Support Mission Speed Histogram.

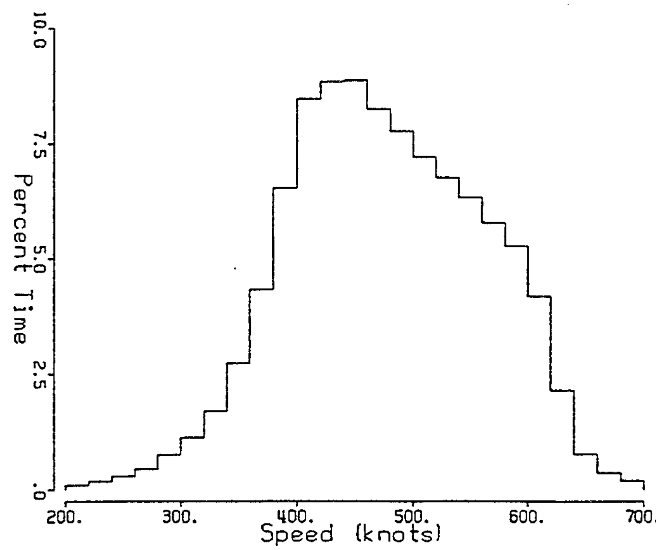


Figure B-17. F-16 Defensive Counter Air Mission Speed Histogram.

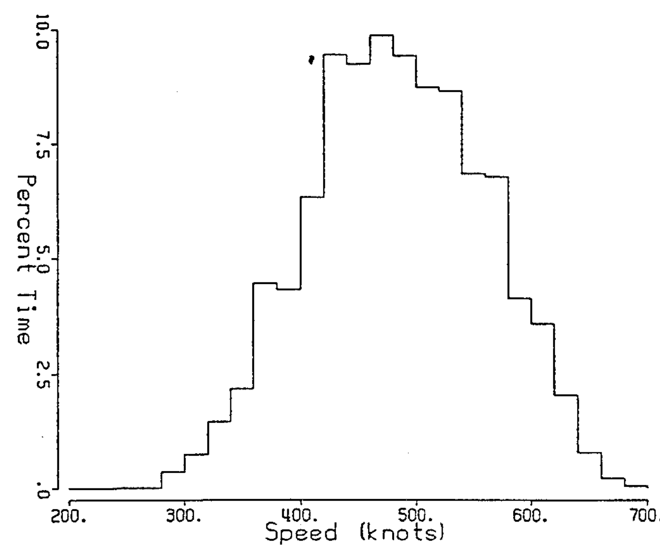


Figure B-18. F-16 Escort Mission Speed Histogram.

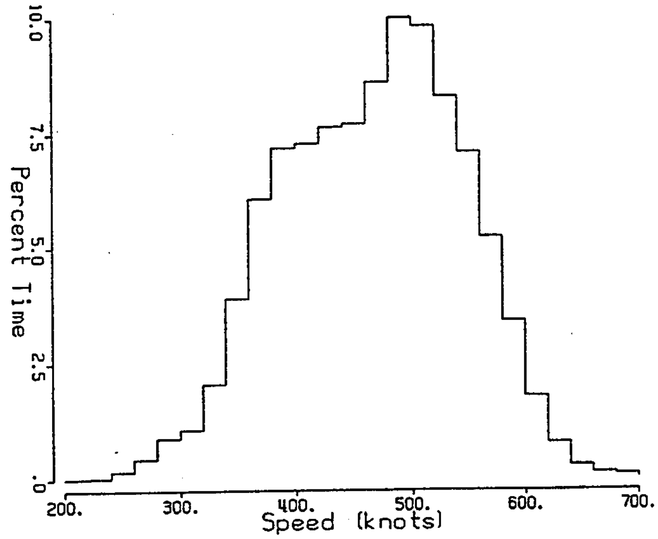


Figure B-19. F-16 Interdiction Mission Speed Histogram.

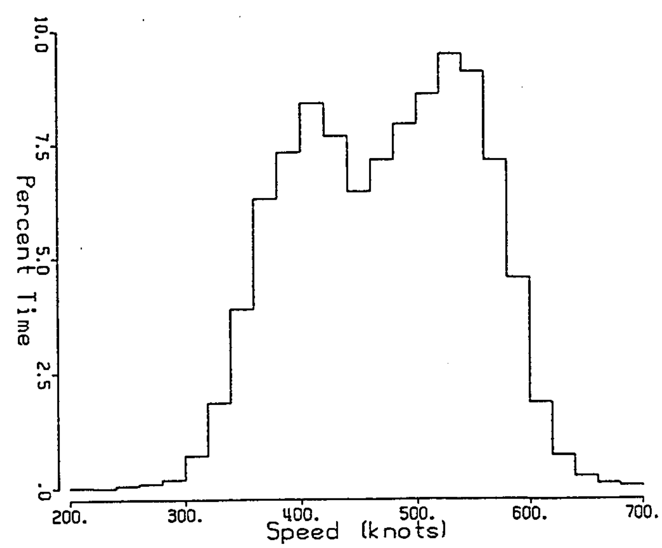


Figure B-20. F-16 Offensive Counter Air Mission Speed Histogram.

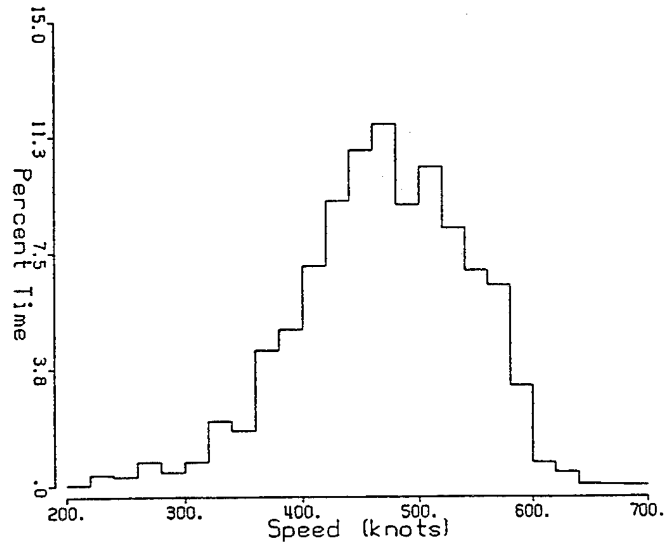


Figure B-21. F-16 All Other Missions Speed Histogram.

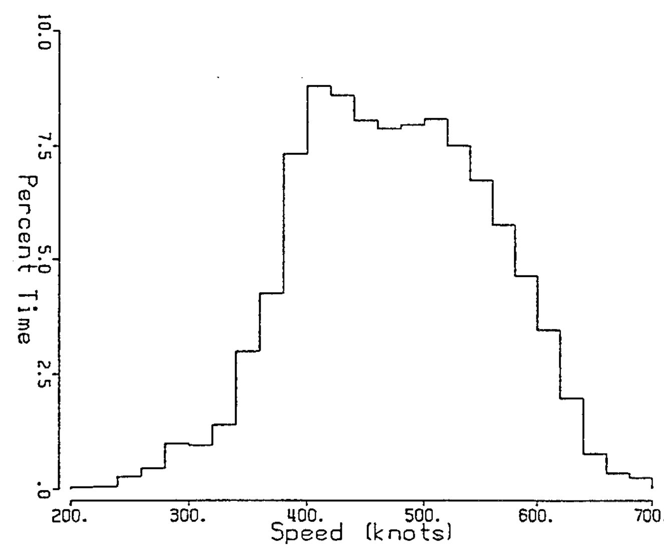


Figure B-22. F-18 Defensive Counter Air Mission Speed Histogram.

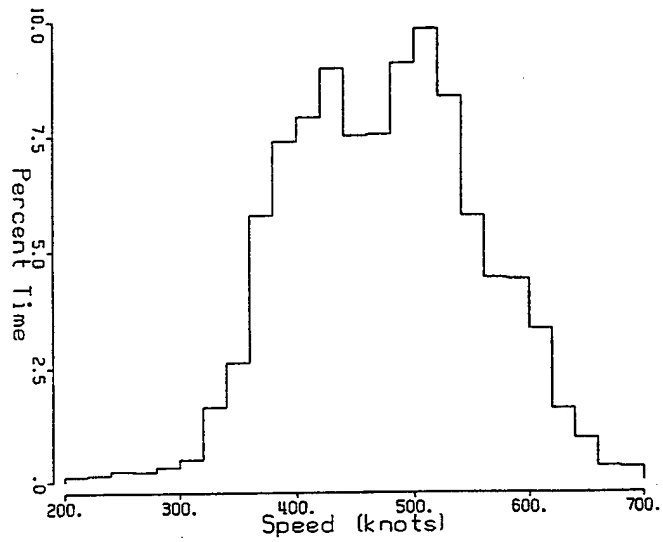


Figure B-23. F-18 Wild Weasel Mission Speed Histogram.

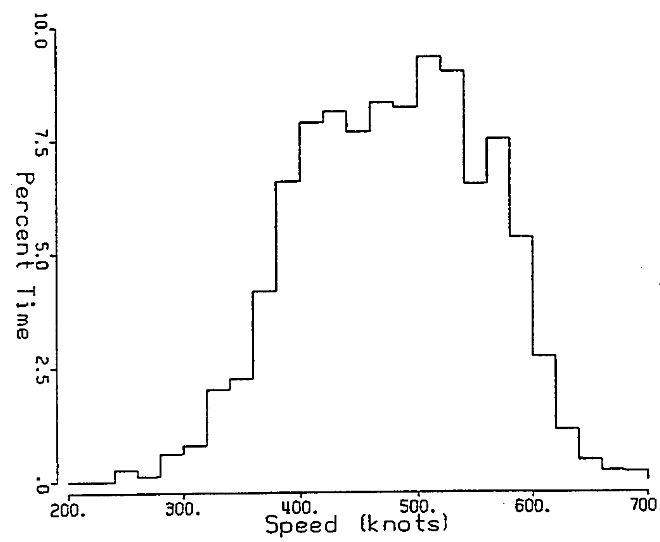


Figure B-24. F-111E Electronic Warfare Mission Speed Histogram.

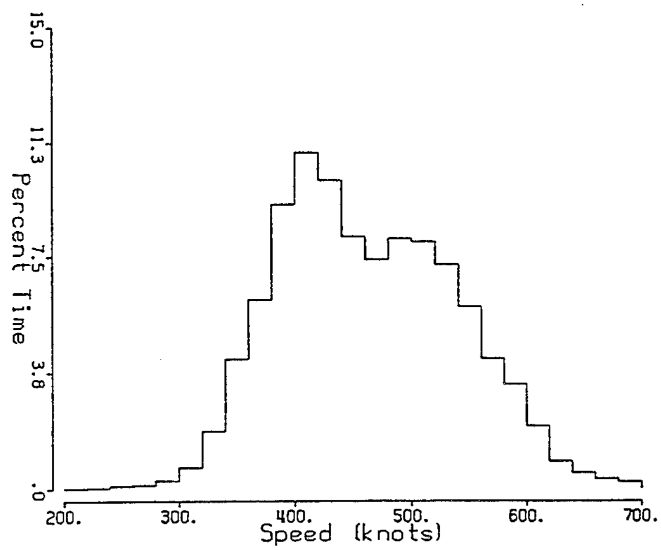


Figure B-25. F-111F Interdiction Mission Speed Histogram.

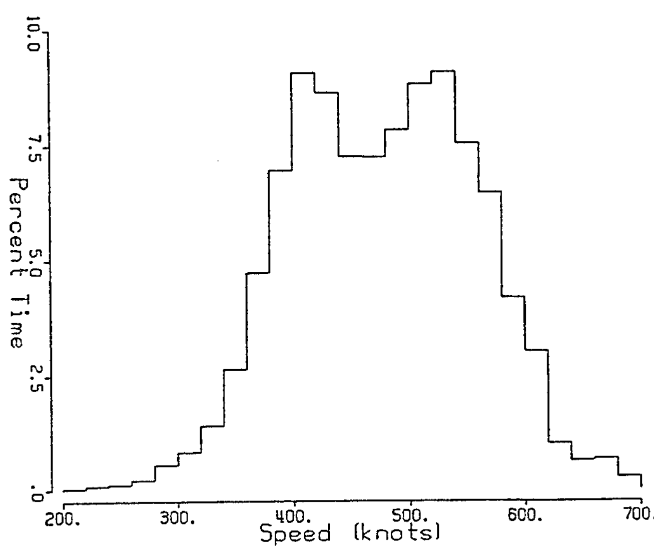


Figure B-26. F-111F Offensive Counter Air Mission Speed Histogram.

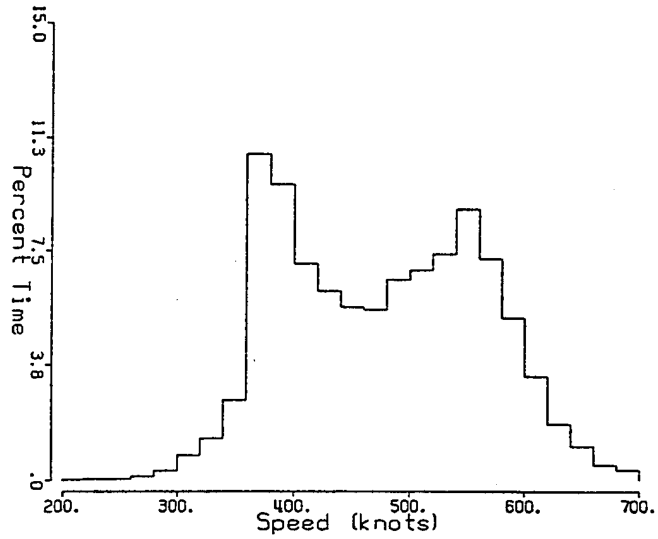


Figure B-27. Tornado Escort Mission Speed Histogram.

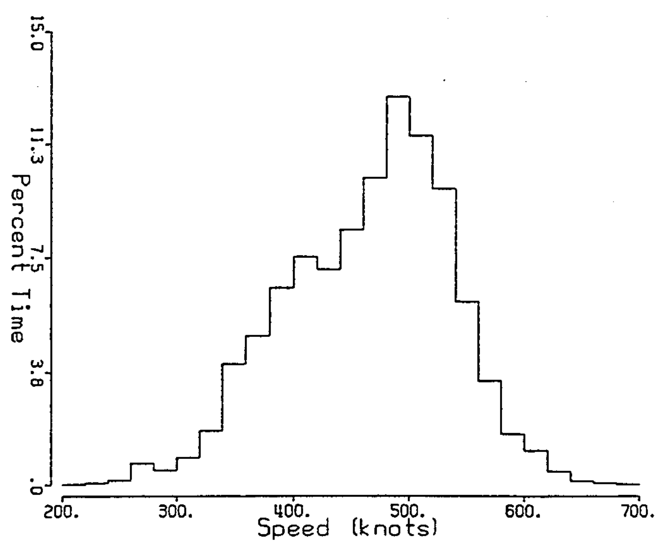


Figure B-28. Tornado Interdiction Mission Speed Histogram.

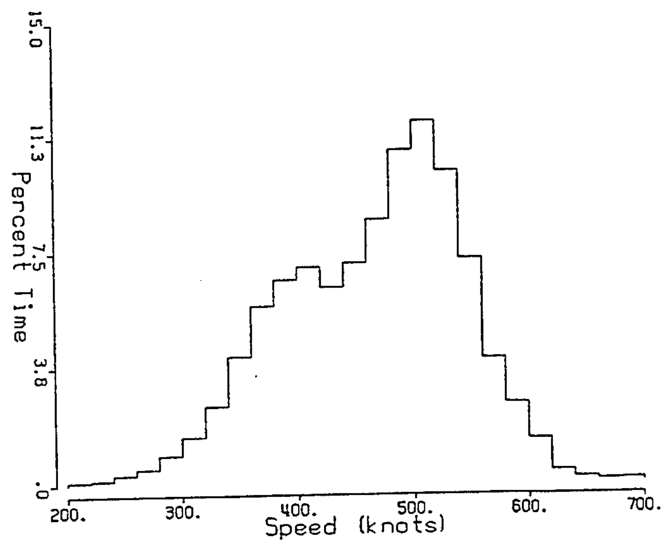


Figure B-29. Tornado Offensive Counter Air Mission Speed Histogram.

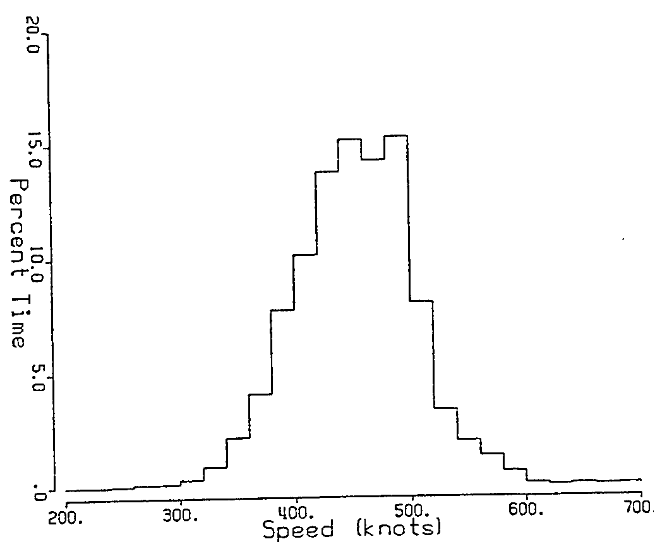


Figure B-30. Tornado All Other Missions Speed Histogram.

APPENDIX C

Keyword Format

APPENDIX C

Keyword Format

This appendix specifies the keyword syntax and describes the procedure for editing the input file. It is not essential to understand the keyword syntax to run MRNMAP. These instructions are provided for users that prefer to edit the file directly rather than use the edit capabilities in MROPS. Keywords are organized in alphabetic order; each keyword name is followed by a description on the keyword usage and a table showing its format.

When MRNMAP reads the input file, certain assumptions are made about the data. These assumptions are as follows:

1. All numeric data is interpreted as an integer number.
2. All lowercase characters are interpreted as uppercase characters.
3. All length dimensions are in units of feet.
4. Altitude is in units of feet above ground level (AGL).
5. A mission name may only be used once under the MISSION keyword.
6. An airspace name may only be used once under the MOA and TRACK SPECIFICATION keywords.

Editing or creating an input file outside of MROPS can introduce errors. MRNMAP has error-checking features that identify most of the common errors users make. Sometimes, however, an error will evade MRNMAP error checking features, causing the program to terminate unexpectedly. See Section 4.1.3.2, Control and Reporting Keywords, for hints on finding and resolving input file errors.

Keyword **AREA SPEC**

AREA SPEC specifies the MOA area, floor, and ceiling. The maximum number of AREA SPEC plus MOA SPEC keywords permitted in the input file is 25. This keyword is not available from MROPS. Shown in Table C-1 is the keyword format.

Table C-1

AREA SPEC Keyword Format

Line No.	Columns 1-10	Columns 11-20
1	Name of the MOA Maximum of 25 Characters	
2	MOA Area in Square Feet	
3	Floor of MOA in feet AGL	Ceiling of MOA in feet AGL

Keyword **AVOIDANCE**

AVOIDANCE specifies the center, radius, and ceiling of an avoidance area. The maximum number of AVOIDANCE keywords permitted in the input file is 25. Shown in Table C-2 is the keyword format.

Table C-2

AVOIDANCE Area KeywordFormat
(N = Number of avoidance areas)

Line Number	Columns 1-10	Columns 11-20	Columns 21-30	Columns 31-40	Columns 41-50	Columns 51-60
1	Number of Avoidance Areas					
2 ⋮	Name of Avoidance Area Maximum of 20 Characters		X-Coordinate	Y-Coordinate	Radius in Feet	Ceiling in Feet AGL
N+1	Name of Avoidance Area Maximum of 20 Characters		X-Coordinate	Y-Coordinate	Radius in Feet	Ceiling in Feet AGL

Keyword **IMPORT SEL**

IMPORT SEL specifies the noise level versus distance relationship. This keyword is used in place of the NOISEFILE acoustical data set. To activate this option enter an ID Code of 999 under the MISSION keyword and be sure to use the same mission name under the MISSION keyword as appears under the IMPORT SEL keyword. The IMPORT SEL keyword must appear after the MISSION keyword that it references. The maximum number of IMPORT SEL keywords is 50. This keyword is not available from MROPS. Shown in Table C-3 is the keyword format.

Table C-3

IMPORT SEL Keyword Format

Line Number	Columns 1-10	Columns 11-20	Columns 21-30	Columns 31-40	Columns 41-50
1	Mission Name 10 Characters				
2	Air to Ground at 100 feet	Air to Ground at 125 feet	Air to Ground at 160 feet	Air to Ground at 200 feet	Air to Ground at 250 feet
3	Air to Ground at 314 feet	Air to Ground at 400 feet	Air to Ground at 500 feet	Air to Ground at 630 feet	Air to Ground at 800 feet
4	Air to Ground at 1,000 feet	Air to Ground at 1,250 feet	Air to Ground at 1,600 feet	Air to Ground at 2,000 feet	Air to Groun dat 2,500 feet
5	Air to Ground at 3,150 feet	Air to Ground at 4,000 feet	Air to Ground at 5,000 feet	Air to Ground at 6,300 feet	Air to Ground at 8,000 feet
6	Air to Ground at 10,000 feet	Air to Ground at 12,500 feet	Air to Ground at 16,000 feet	Air to Ground at 20,000 feet	Air to Ground at 25,000 feet
7	Grnd to Grnd at 100 feet	Grnd to Grnd at 125 feet	Grnd to Grnd at 160 feet	Grnd to Grnd at 200 feet	Grnd to Grnd at 250 feet
8	Grnd to Grnd at 100 feet	Grnd to Grnd at 125 feet	Grnd to Grnd at 160 feet	Grnd to Grnd at 200 feet	Grnd to Grnd at 250 feet
9	Grnd to Grnd at 1,000 feet	Grnd to Grnd at 1,250 feet	Grnd to Grnd at 1,600 feet	Grnd to Grnd at 2,000 feet	Grnd to Grnd at 2,500 feet
10	Grnd to Grnd at 3,150 feet	Grnd to Grnd at 4,000 feet	Grnd to Grnd at 5,000 feet	Grnd to Grnd at 6,300 feet	Grnd to Grnd at 8,000 feet
11	Grnd to Grnd at 10,000 feet	Grnd to Grnd at 12,500 feet	Grnd to Grnd at 16,000 feet	Grnd to Grnd at 20,000 feet	Grnd to Grnd at 25,000 feet

Keyword **LOCATION**

LOCATION specifies the lower left and upper right corners of the grid in world coordinates. The ground elevation converts the MSL altitudes supplied in the FAA MTR database to AGL. This keyword is required by MROPS to draw the screen graphics. The LOCATION keyword is not necessary if the user plans to run MRNMAP without the use of MROPS. Shown in Table C-4 is the keyword format.

Table C-4

LOCATION Keyword Format

USAGE:

Line No.	Columns 1-10	Columns 11-20	Columns 21-30	Columns 31-40
1	Latitude Lower Left Corner		Longitude Lower Left Corner	
2	Latitude Upper Right Corner		Longitude Upper Right Corner	
3	Ground Elevation in feet AGL			

Keyword **MISSION**

MISSION specifies the aircraft mission profile. The elements of a mission profile are the aircraft ID code, the power and speed setting, and the altitude profile. The aircraft ID codes and the default power and speed settings are shown in Appendix B.

The altitude profile is entered in terms of a lower and upper altitude pair. Appearing beside each altitude pair is the percent time or time in minutes the aircraft spends between the two altitude limits. A maximum of ten altitude pairs can be entered for each mission. The altitude profile must begin at the lowest altitude and be contiguous from one altitude pair to the next. Consider the profile shown in Table C-5.

Table C-5

Example Altitude Profile Specified as Percent Time

Lower Altitude Feet AGL	Upper Altitude Feet AGL	Percent Time
100	250	30
250	500	40
500	1000	30

Suppose the total sortie time is 30 minutes; then an equivalent profile is shown in Table C-6.

Table C-6

Example Altitude Profile Specified in Absolute Units of Time.

Lower Altitude Feet AGL	Upper Altitude Feet AGL	Time in Minutes
100	250	9
250	500	12
500	1000	9

Both profiles will produce the same noise levels, since MRNMAP calculates the weighted average, and does not use the percentages or times directly. Shown in Table C-7 is the keyword format. The maximum number of MISSION keywords is 50.

Table C-7

MISSION Keyword Format
(N = Number of Altitude Pairs)

Line Number	Columns 1–10	Columns 11–20	Columns 21–30
1	Mission Name Max. of 10 Char.		
2	Aircraft ID Code	Speed Setting	Power Setting
3	Number of Altitude Pairs		
4 ⋮	Lower Altitude Limit in Feet AGL	Upper Altitude Limit in Feet AGL	Percent Time or Time in Minutes
N+3	Lower Altitude Limit in Feet AGL	Upper Altitude Limit in Feet AGL	Percent Time or Time in Minutes

Keyword **MOA OPS**

MOA OPS specifies the number of operations in each MOA. The keyword has two parts. The first part lists the MOAs and/or ranges and the percent utilization. The second part lists the mission names and the annual operations. MRNMAP multiples the annual operations by the percent utilization when calculating the number of operations assigned to the individual MOAs. The "Minutes in Airspace" is not multiplied by the percent utilization. Day, evening, and night operations assume 0700 through 2200 to be daytime and 2200 through 0700 to be nighttime for DNL calculations, and 0700 through 1900 to be daytime, 1900 through 2200 to be evening, and 2200 to 0700 to be nighttime for CNEL calculations. If the noise metric is CNEL, evening operations must be entered using a text editor. Shown in Table C-8 is the keyword format.

Table C-8

MOA OPS keyword format
(M = Number of MOAs and N = Number of missions)

Line No.	Columns 1–10	Columns 11–20	Columns 21–30	Columns 31–40	Columns 41–50
1	Number of MOAs				
2 ⋮	Name of the MOA Maximum of 25 Characters			Percent Utilization of Operations	
M+1	Name of the MOA Maximum of 25 Characters			Percent Utilization of Operations	
M+2	Number of Missions				
M+3 ⋮	Name of the Mission	Number of Annual Day Operations	Number of Annual Evening Operations	Number of Annual Night Operations	Minutes in the Airspace
M+N+2	Name of the Mission	Number of Annual Day Operations	Number of Annual Evening Operations	Number of Annual Night Operations	Minutes in the Airspace

Keyword **MOA SPEC**

MOA SPEC specifies the airspace boundaries. The boundary points can be entered clockwise or counterclockwise. Connecting line segments cannot cross. Shown in Table C-9 is the keyword format. The maximum number of MOA SPEC and AREA SPEC keywords is 25 and the maximum number of points defining a MOA boundary is 25. The last boundary point must be the same as the first for closure of the airspace.

Table C-9

MOA SPEC Keyword Format
(N = Number of Points Defining MOA Boundary)

Line No.	Columns 1–10	Columns 11–20	Columns 21–30
1	Name of the MOA Maximum of 25 Characters		
2	Number of points defining MOA Boundary.		
3	X-Coordinate for First Point	Y-Coordinate for First Point	
4 ⋮	X-Coordinate for Second Point	Y-Coordinate for Second Point	
N+2	X-Coordinate for N'th Point	Y-Coordinate for N'th Point	
N+3	Floor of MOA in feet AGL	Ceiling of MOA in feet AGL	

Keyword **SPECIFIC POINT**

SPECIFIC POINT specifies the X and Y location for specific points at which noise levels are to be calculated. Shown in Table C-10 is the keyword format. The maximum number of SPECIFIC POINT keywords is 25. This keyword is not available from MROPS.

Table C-10

SPECIFIC POINT Keyword Format
(N = Number of Specific Points)

Line Number	Columns 1–10	Columns 11–20	Columns 21–30	Columns 31–40
1	Number of Specific Points			
2 ⋮	Name of Specific Point Maximum of 20 Characters		X-Coordinate	Y-Coordinate
N+1	Name of Specific Point Maximum of 20 Characters		X-Coordinate	Y-Coordinate

Keyword **SETUP PARA**

SETUP PARA specifies basic grid and airspace parameters. SETUP PARA must appear at the very beginning of the input file. When MROPS is used to create the input file, the X and Y values for the two grid corners are in UTM coordinates which have been converted to units of feet. Shown in Table C-11 is the keyword format.

Table C-11

SETUP PARA Keyword Format

Line Number	Columns 1–10	Columns 11–20	Columns 21–30
1	Number of MOAs	Number of Tracks	
2	Grid Point Spacing in feet		
3	X-Coordinate Lower Left Corner of Grid	Y-Coordinate Lower Left Corner of Grid	
4	X-Coordinate Upper Right Corner of Grid	Y-Coordinate Upper Right Corner of Grid	
5	Air Temperature in Degrees Fahrenheit Sug. Val. 59°F	Percent Relative Humidity Suggested Value 70%	Number of Days in a Month Suggested Value 30
6	Number of Events Cutoff Level Suggested Value 65 dB		

Keyword **TRACK OPS**

TRACK OPS specifies the number of operations on each track. The keyword has two parts. The first part lists the tracks and the percent utilization. The second part lists the names of the associated missions and the number of annual operations. The program multiplies the mission annual operations by the percentages when calculating the number of operations assign to the individual tracks. The keyword is very similar to MOA OPS with the exception that the minutes in airspace are not required for tracks. Shown in Table C-12 is the keyword format.

Table C-12

TRACK OPS Keyword Format
(M = Number of Tracks and N = Number of Missions)

USAGE:

Line Number	**Columns 1–10**	**Columns 11–20**	**Columns 21–30**	**Columns 31–40**
1	Number of Tracks			
2 ⋮	Name of the Track Maximum of 20 Characters			Percent Utilization of Operations
M+1	Name of the Track Maximum of 20 Characters			Percent Utilization of Operations
M+2	Number of Missions			
M+3	Name of the Mission	Number of Annual Day Operations	Number of Annual Evening Operations	Number of Annual Night Operations
M+N+2	Name of the Mission	Number of Annual Day Operations	Number of Annual Evening Operations	Number of Annual Night Operations

Keyword **TRACK SPEC**

TRACK SPEC specifies the flight track coordinates. As input the keyword requires the X and Y coordinates, the lateral dispersion, and the floor. When the track has a turn segment, the data input includes the turn radius, the change in heading in degrees, and the floor at the turn entry and exit points.

A turn point is defined in this document as the starting point of each line segment. Each turn point occupies a single line of data. Two flags appear at the beginning of each line. These flags signal the line type to MRNMAP. Shown in Table C-13 is a summary of the flags.

Table C-13

Flags Used by MRNMAP to Denote the Line Type

Flag Appearing in Column 1	Flag Appearing in Column 2	Meaning
L	W	Straight line segment. Left and right width supplied.
L	S	Straight line segment. Standard deviation supplied.
T	W	Turning segment. Left and right width supplied.
T	S	Turning line segment. Standard deviation supplied.
N	W	Straight line segment. Standard deviation or altitude are NOT the same at the two ends. Left and right width supplied.
N	S	Straight line segment. Standard deviation or altitude are NOT the same at the two ends. Standard deviation supplied.

Adjacent to the flags are numeric data that specify the other track attributes at each turn point. This data is dependent on the choice of flags used in Table A-13. Shown in Table C-14 are the data structures for the six possible turn point combinations. In this table all dimensions are in feet and the turn angle is in degrees. A positive sign will be used to denote a right-hand turn and a negative sign indicates a left-hand turn.

Table C-14

Input Data Syntax Used to Define a Line Segment

Col. 1–2	Column 11–20	Column 21–30	Column 31–40	Column 41–50	Column 51–60	Column 61–70	Column 71–80	Column 81–90
LW	X-Coor	Y-Coor	Left Width	Right Width	Floor			
LS	X-Coor	Y-Coor	Standard Deviation		Floor			
TW	X-Coor	Y-Coor	Left Width	Right Width	Floor Turn Entry	Floor Turn Exit	Turn Radius	Turn Angle
TS	X-Coor	Y-Coor	Standard Deviation		Floor Turn Entry	Floor Turn Exit	Turn Radius	Turn Angle
NW	X-Coor	Y-Coor	Left Width	Right Width	Floor			
NS	X-Coor	Y-Coor	Standard Deviation		Floor			

Shown in Table C-15 is the keyword format. The turn points, beginning at line 3 and continuing on, follow the format shown in Table A-14. The number of turn points is always one more than the number of line segments. In the table below, N corresponds to the number of turn points and N-1 equals the number of connecting line segments. The maximum number of TRACK SPEC keywords is 25 and the maximum number of turn points per track is 50.

Table C-15

TRACK SPEC Keyword Format
(N = Number of turn points)

Line Number	**Columns 1–10**	**Columns 11–20**	**Columns 21–90**
1	Name of Track Maximum of 20 Characters		
2	Number of Turn Points		
3	First Turn Point		
4 ⋮	Second Turn Point		
N+2	N'th Turn Point		

APPENDIX D

Naval Air Warfare Center China Lake Ground Tracks Recorded From Radar, 90 Days of Monitoring

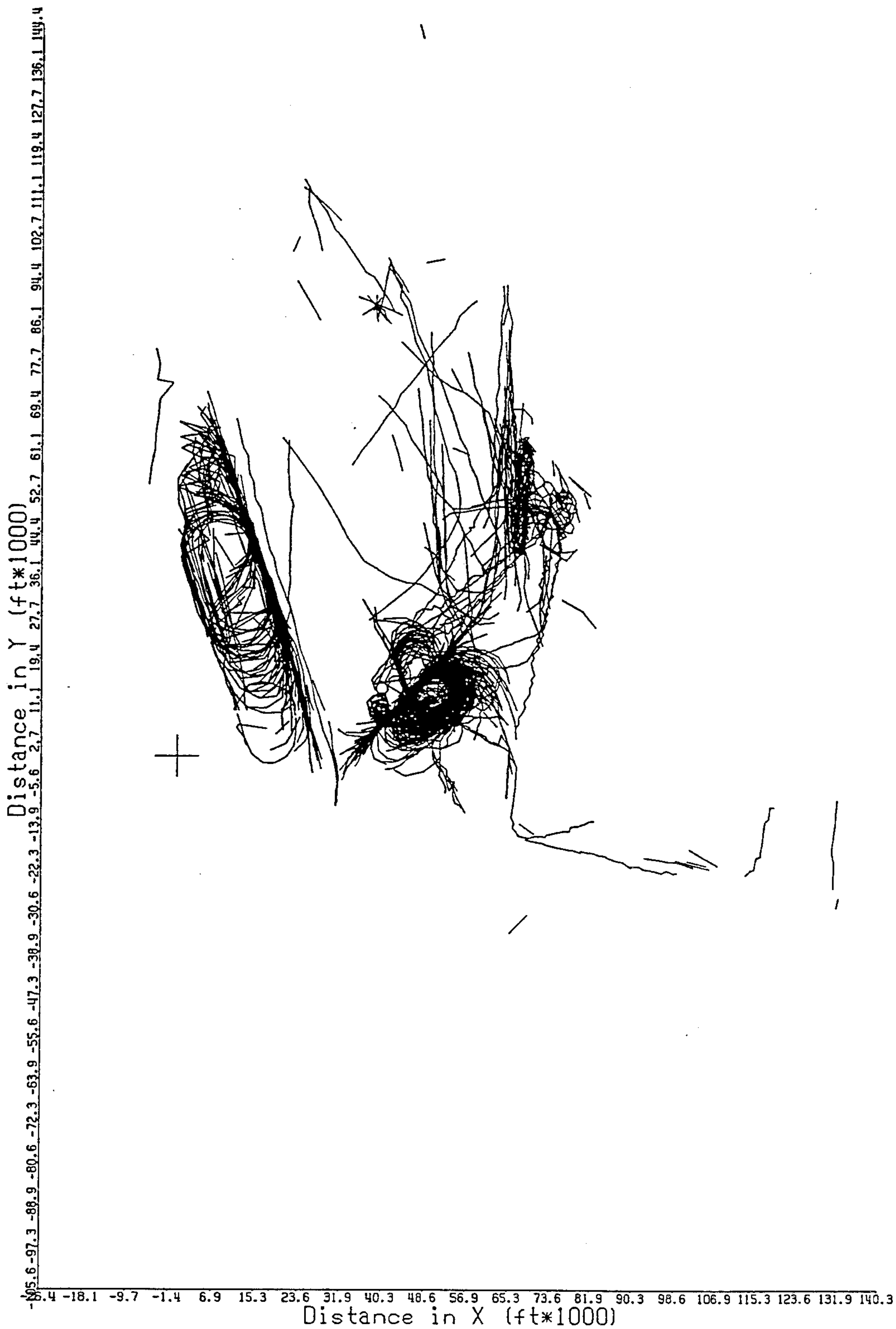


Figure D-1. F-18 Ground Tracks for Operations Between 2,000 and 3,000 Feet MSL.

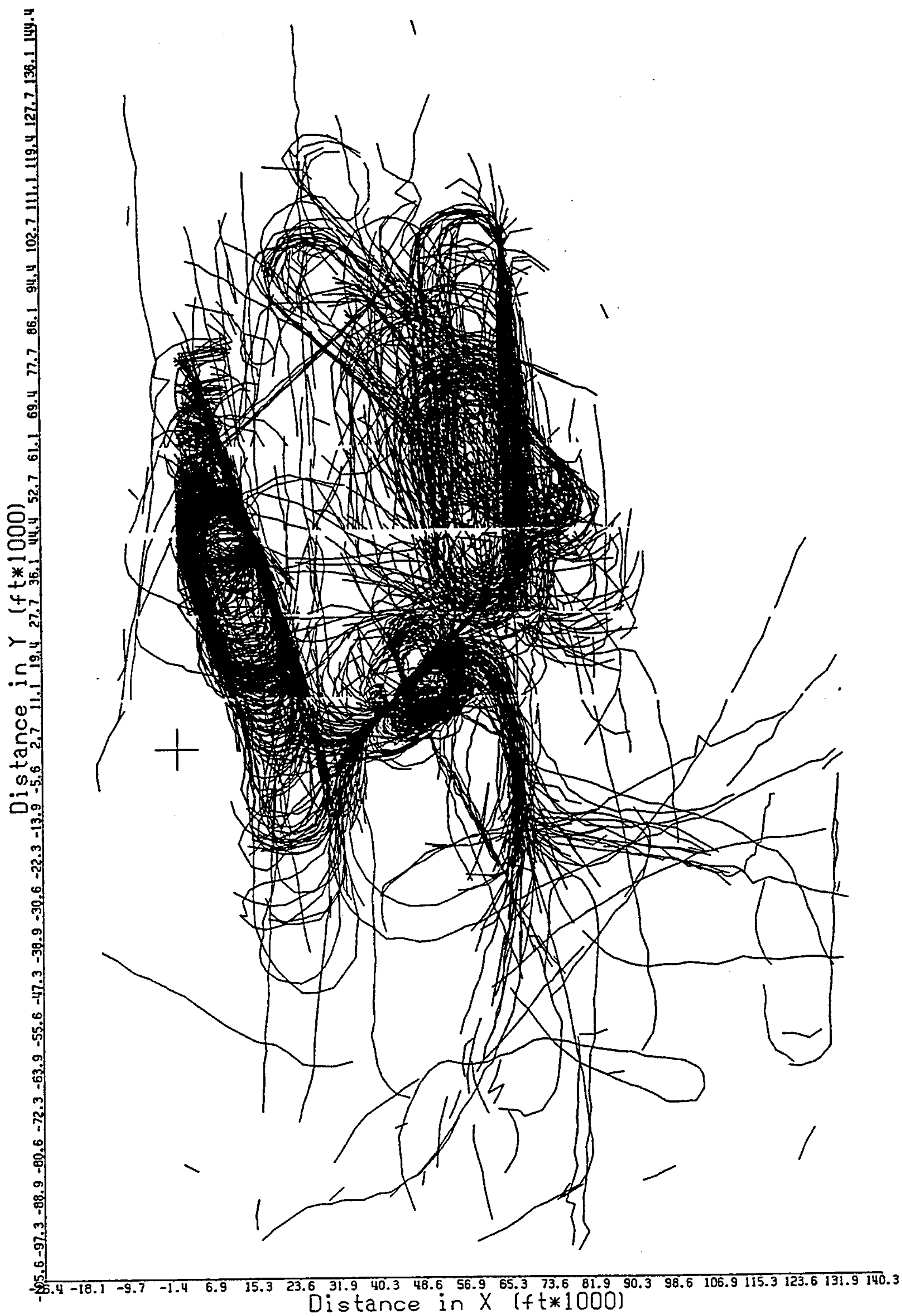


Figure D-2. F-18 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

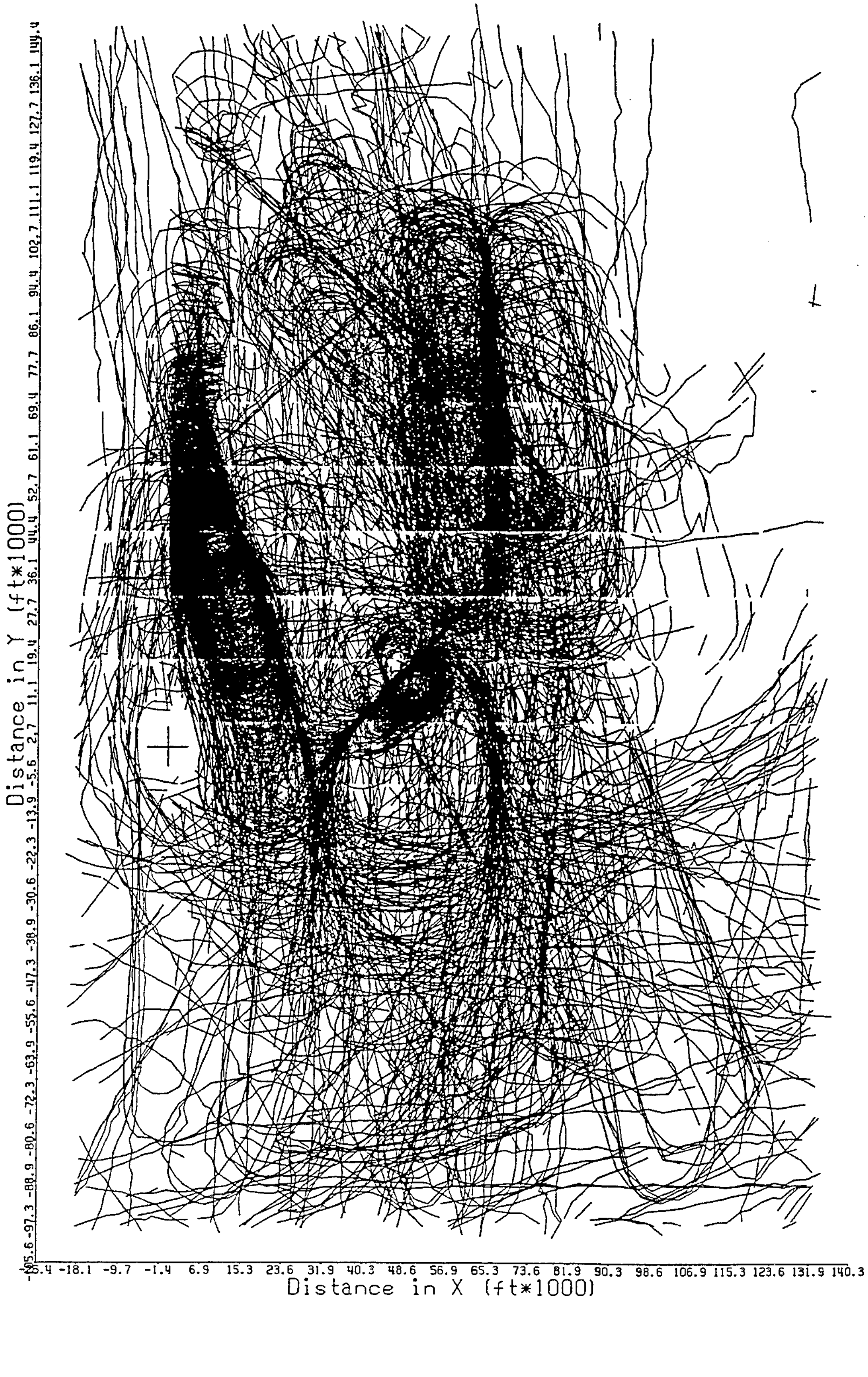


Figure D-3. F-18 Ground Tracks for Operations Between 2,000 and 10,000 Feet MSL.

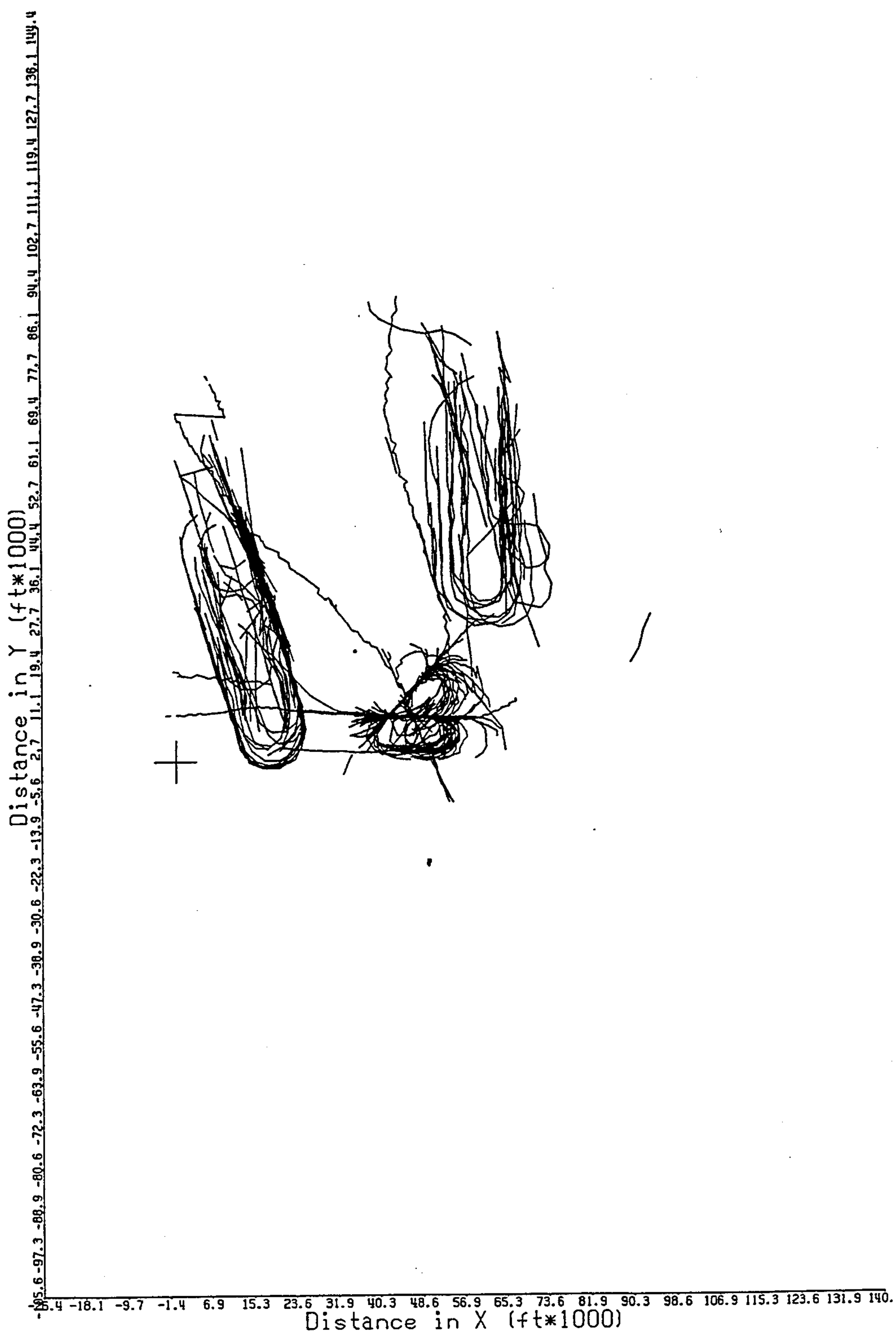


Figure D-4. AV-8 Ground Tracks for Operations Between 2,000 and 3,000 Feet MSL.

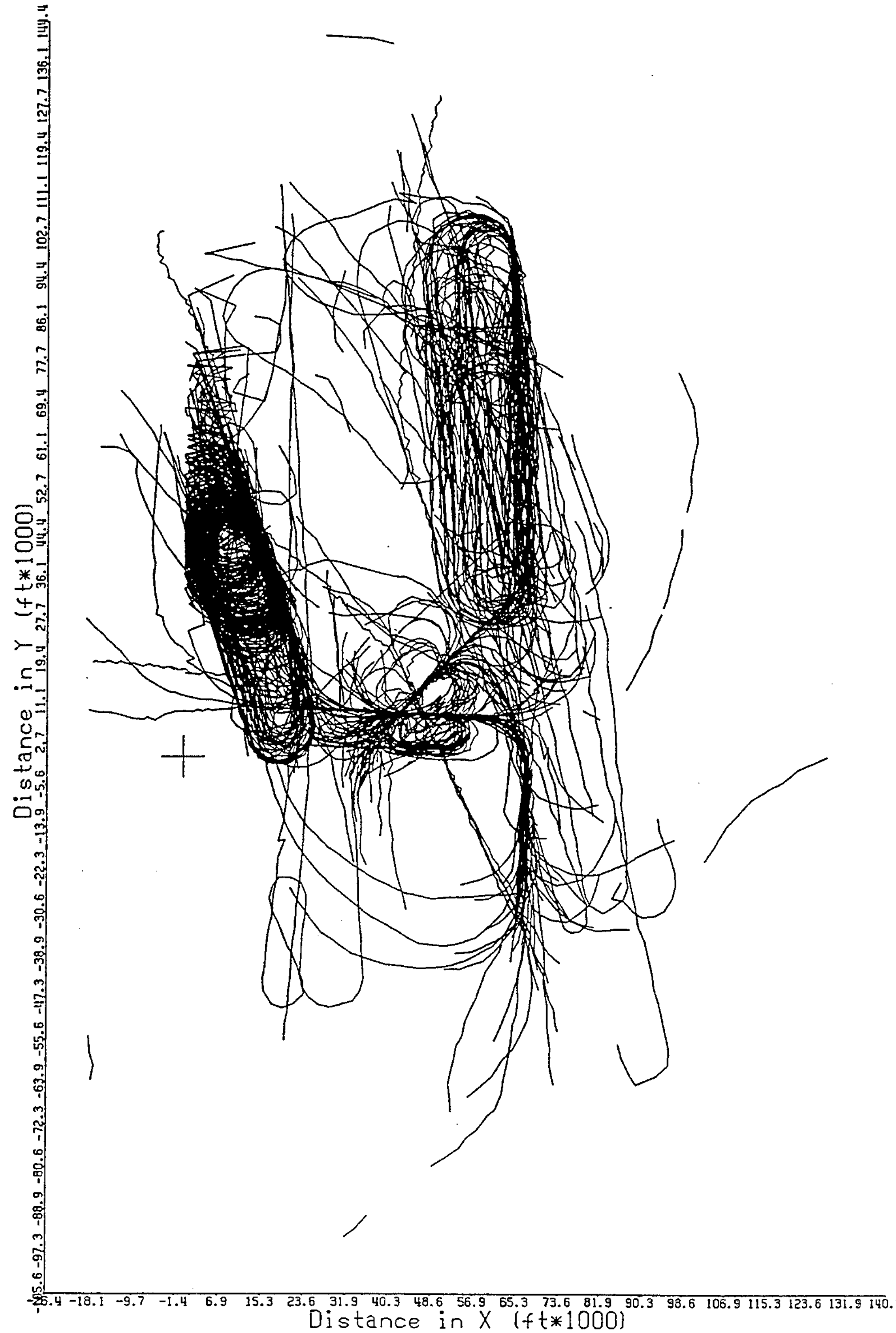


Figure D-5. AV-8 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

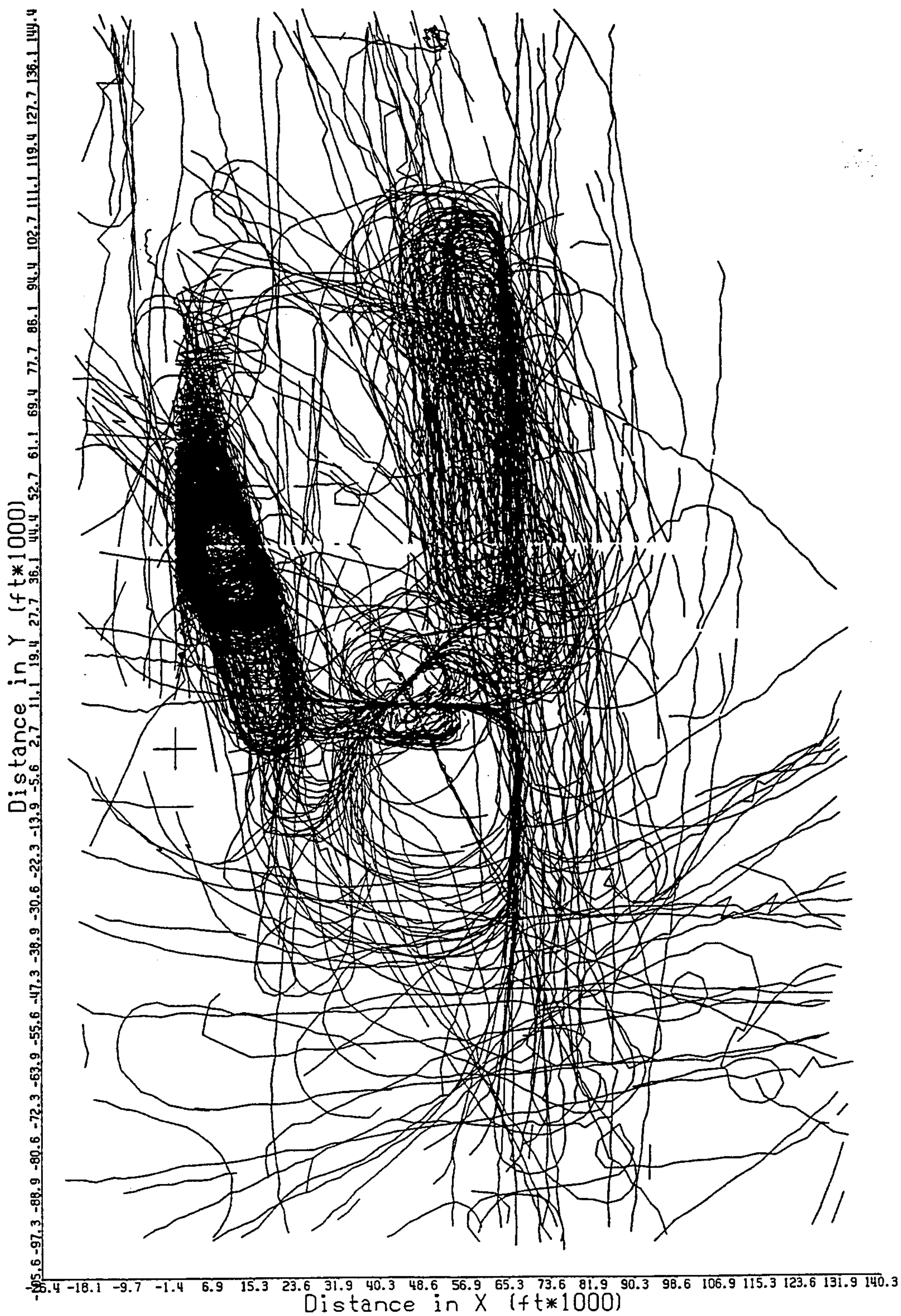


Figure D-6. AV-8 Ground Tracks for Operations Between 2,000 and 10,000 Feet MSL.

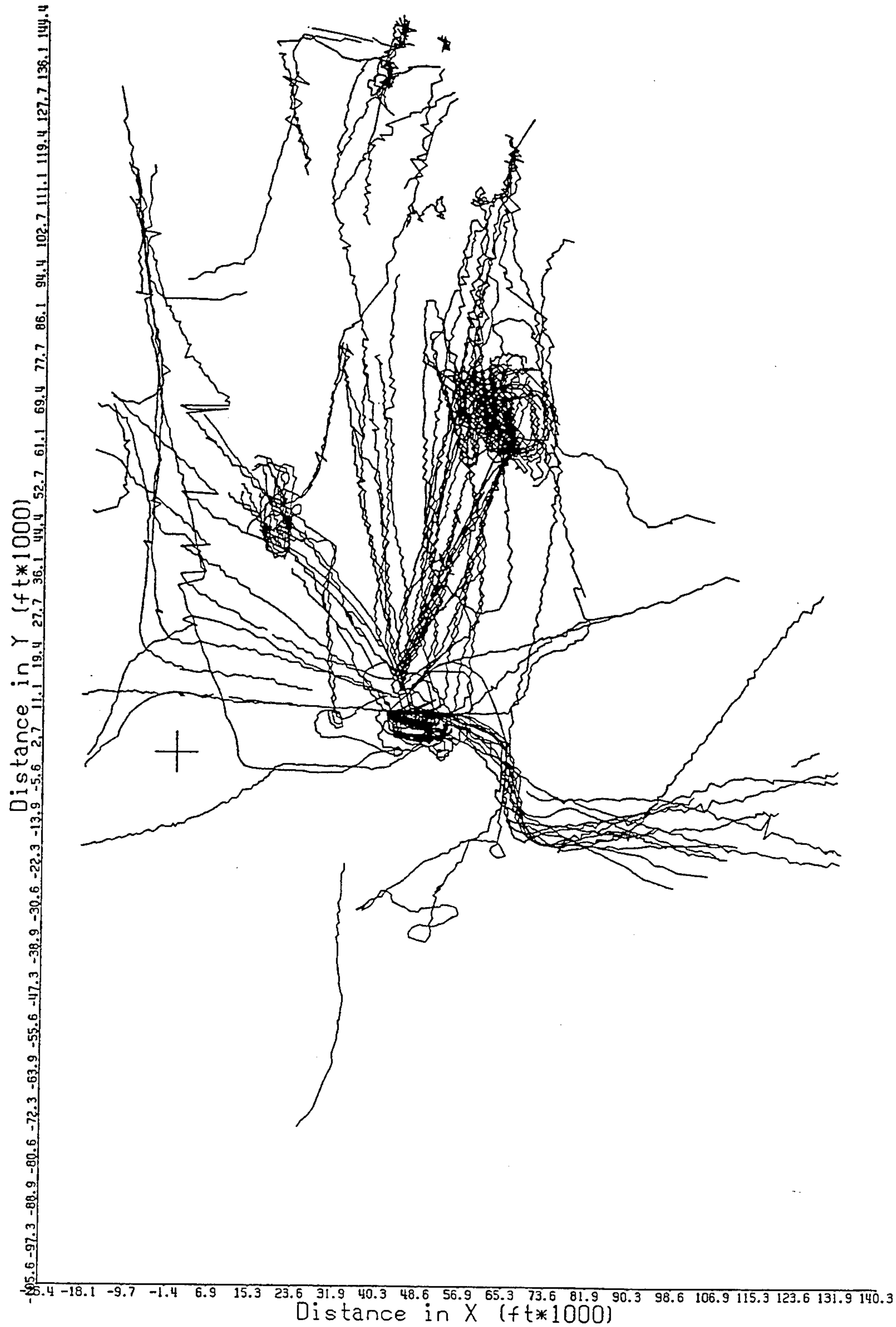


Figure D-7. H-1 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

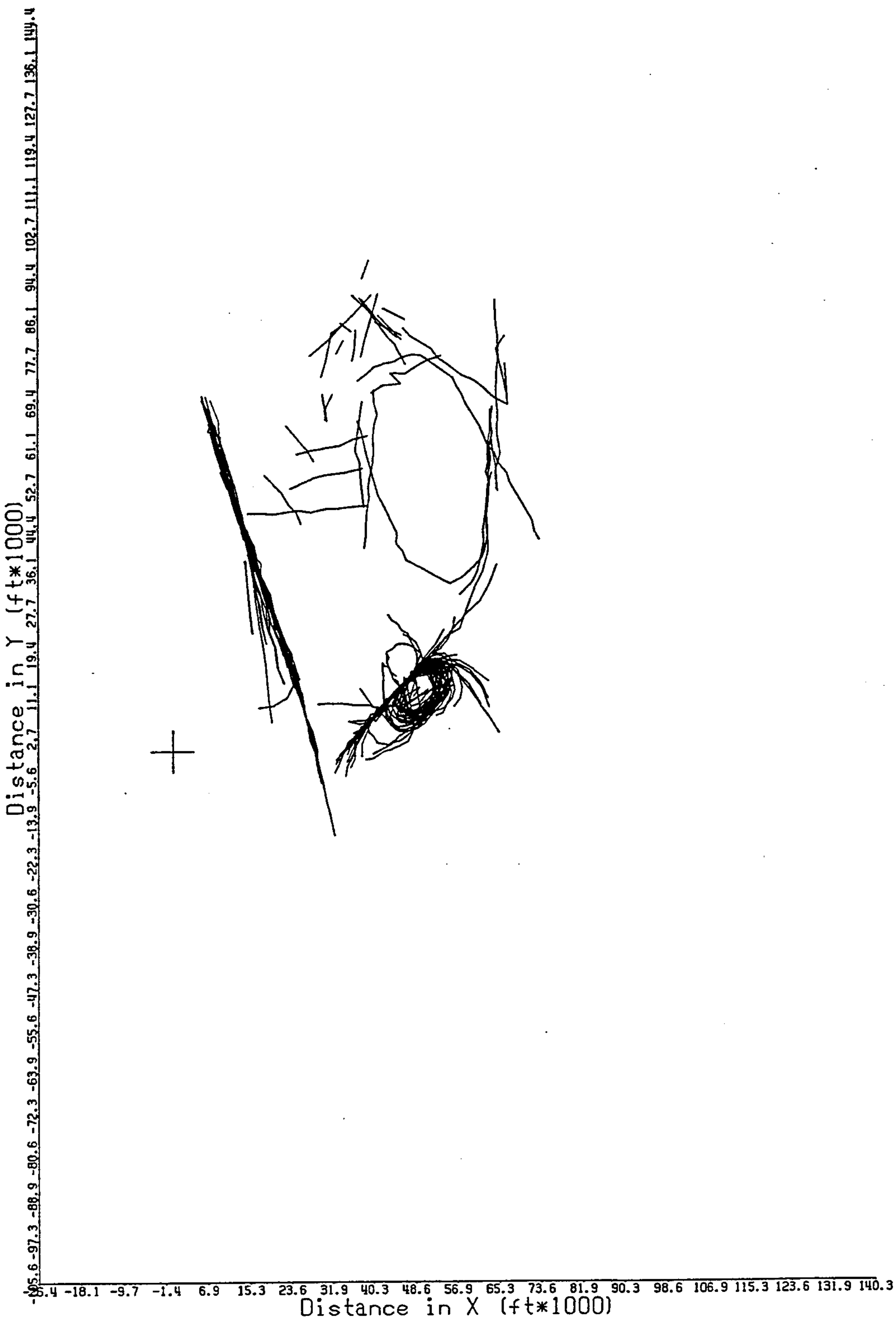


Figure D-8. A-6 Ground Tracks for Operations Between 2,000 and 3,000 Feet MSL.

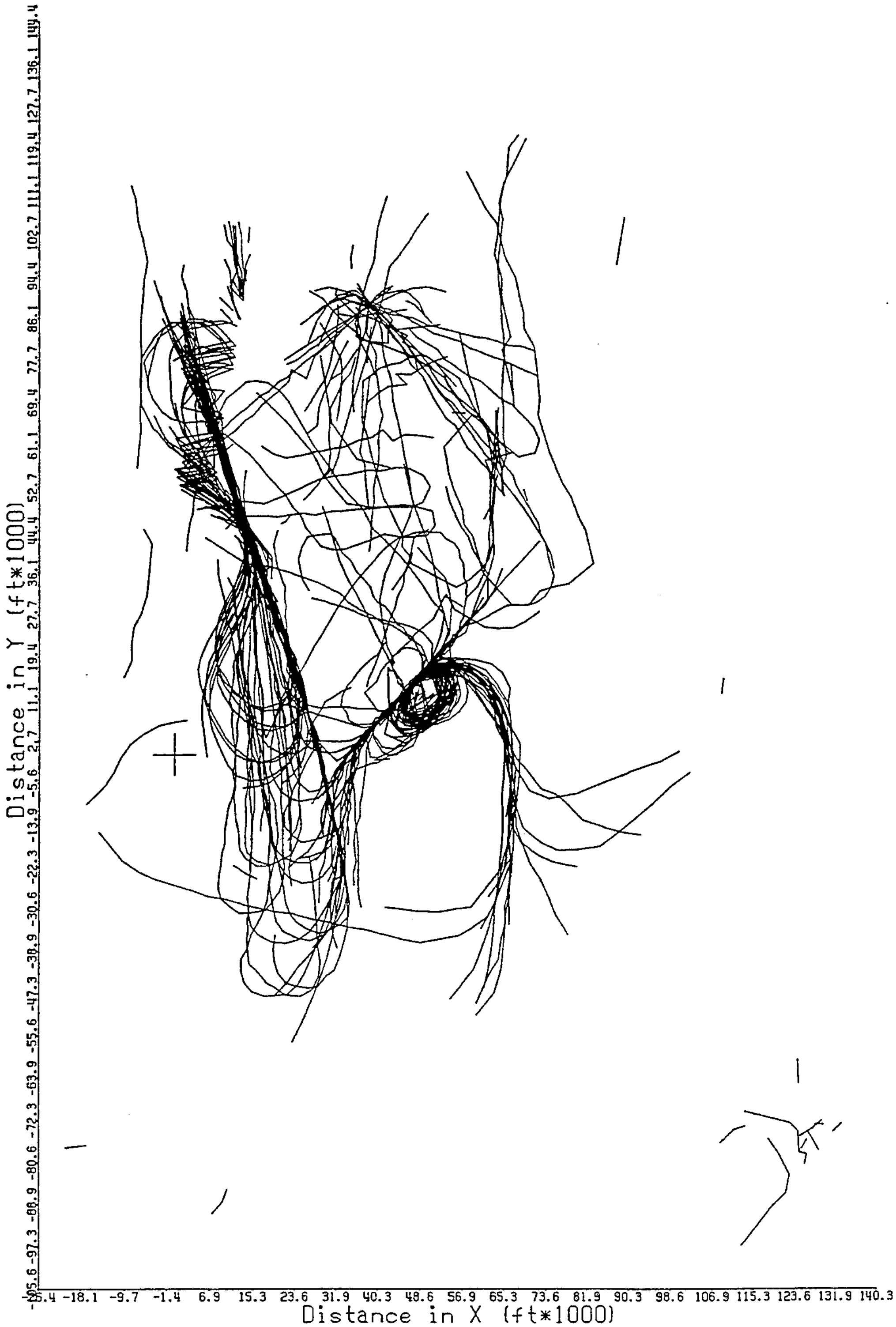


Figure D-9. A-6 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

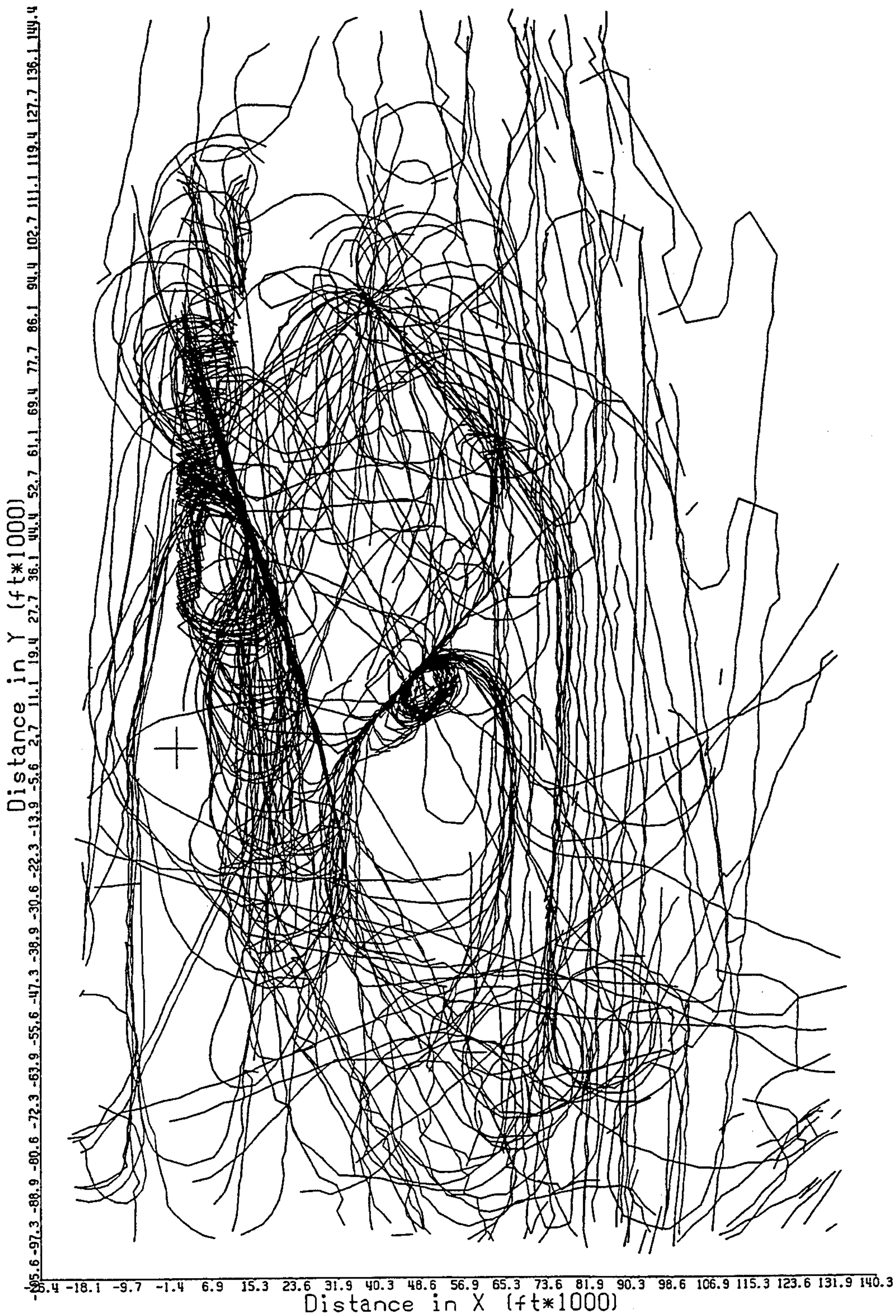


Figure D-10. A-6 Ground Tracks for Operations Between 2,000 and 10,000 Feet MSL.

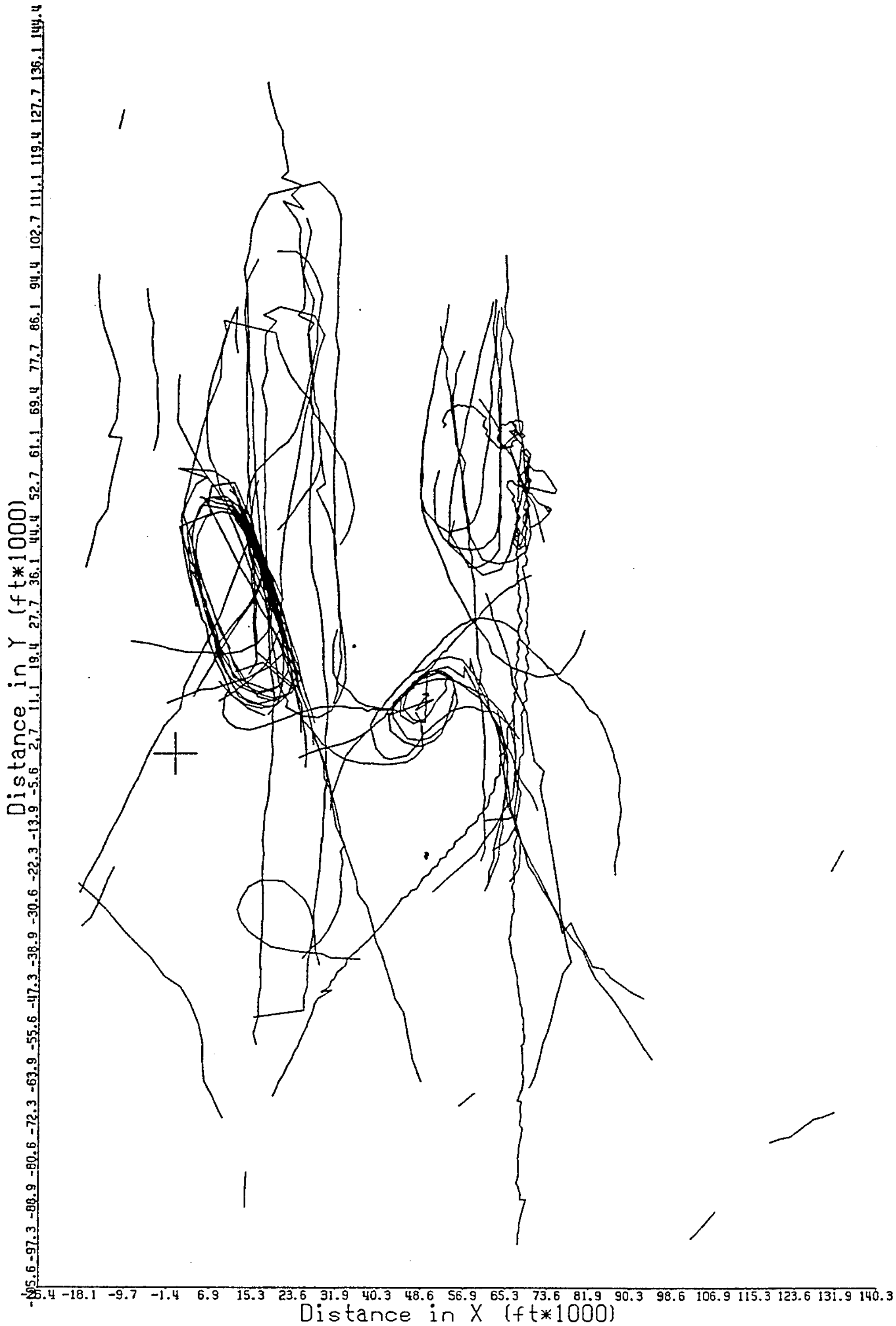


Figure D-11. F-14 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

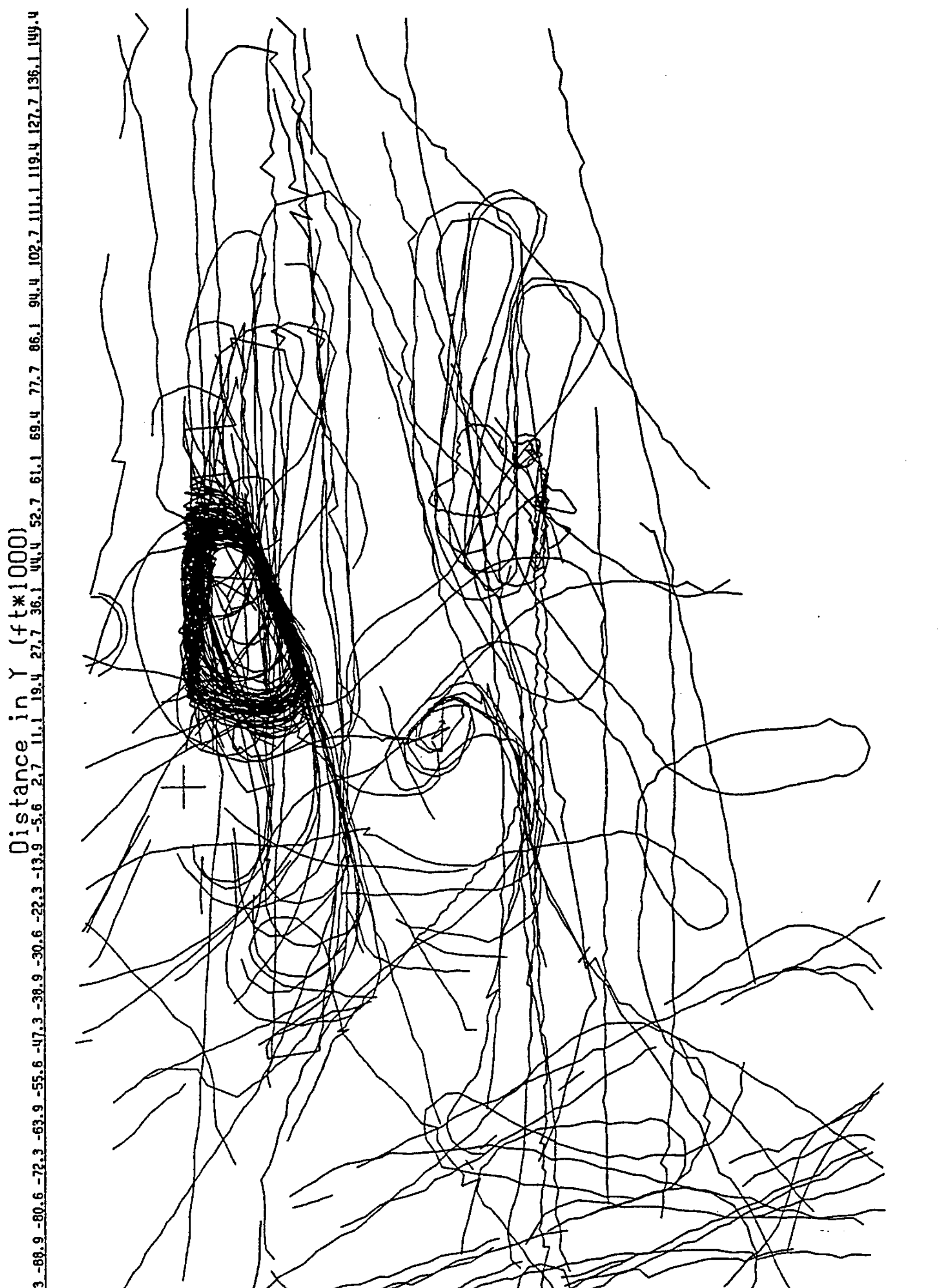


Figure D-12. F-14 Ground Tracks for Operations Between 2,000 and 10,000 Feet MSL.

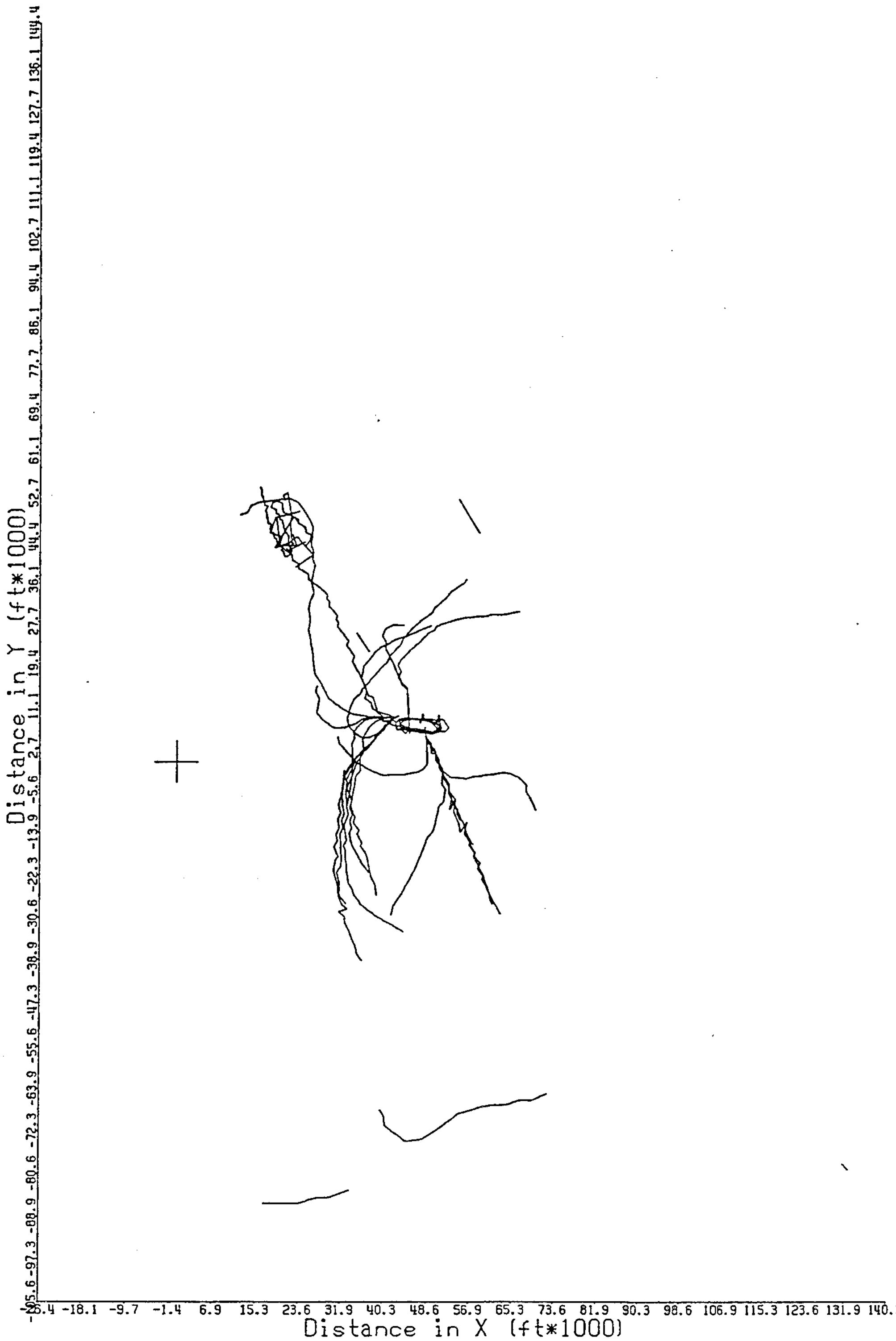


Figure D-13. C-130 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

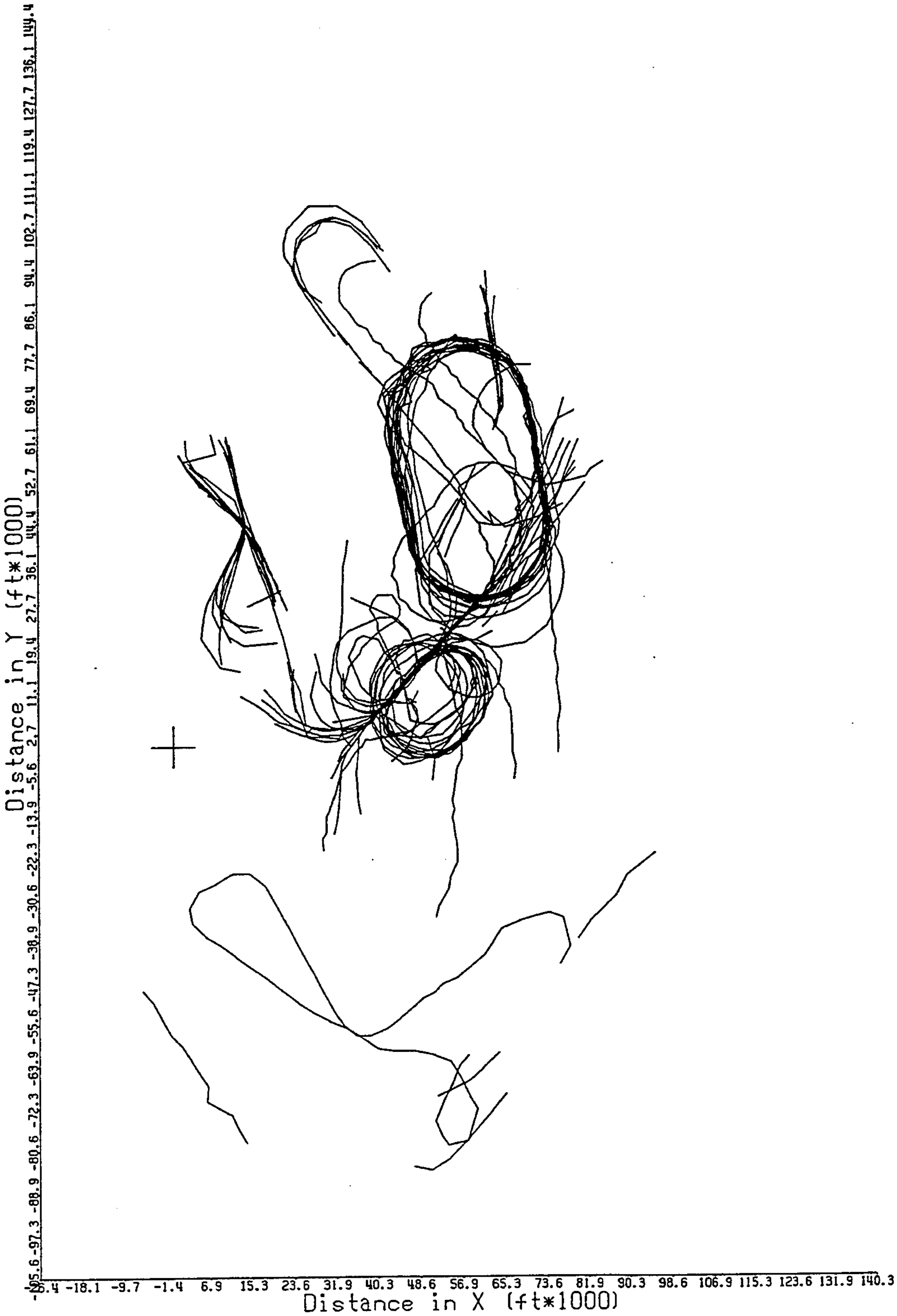


Figure D-14. F-4 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

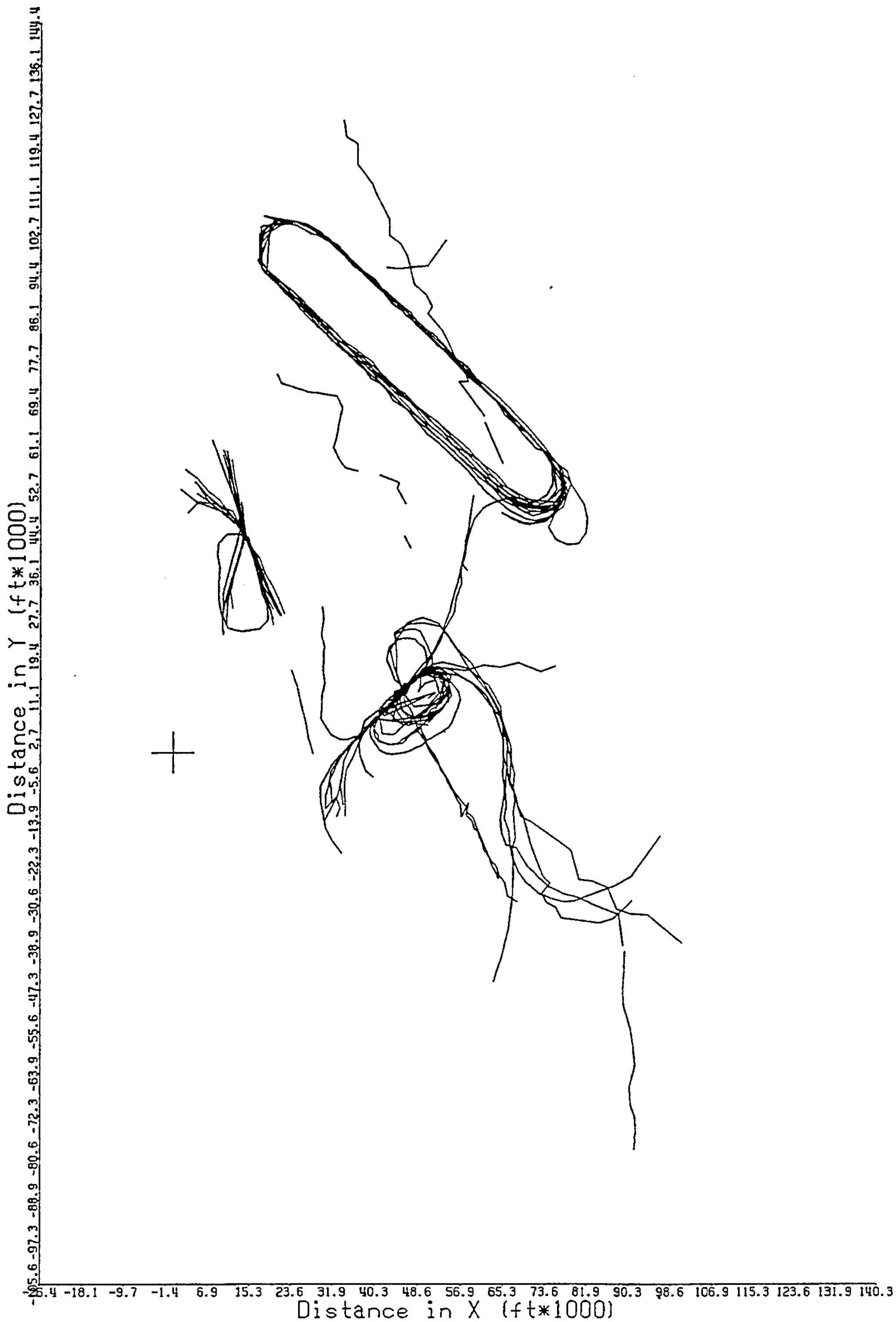


Figure D-15. A-4 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

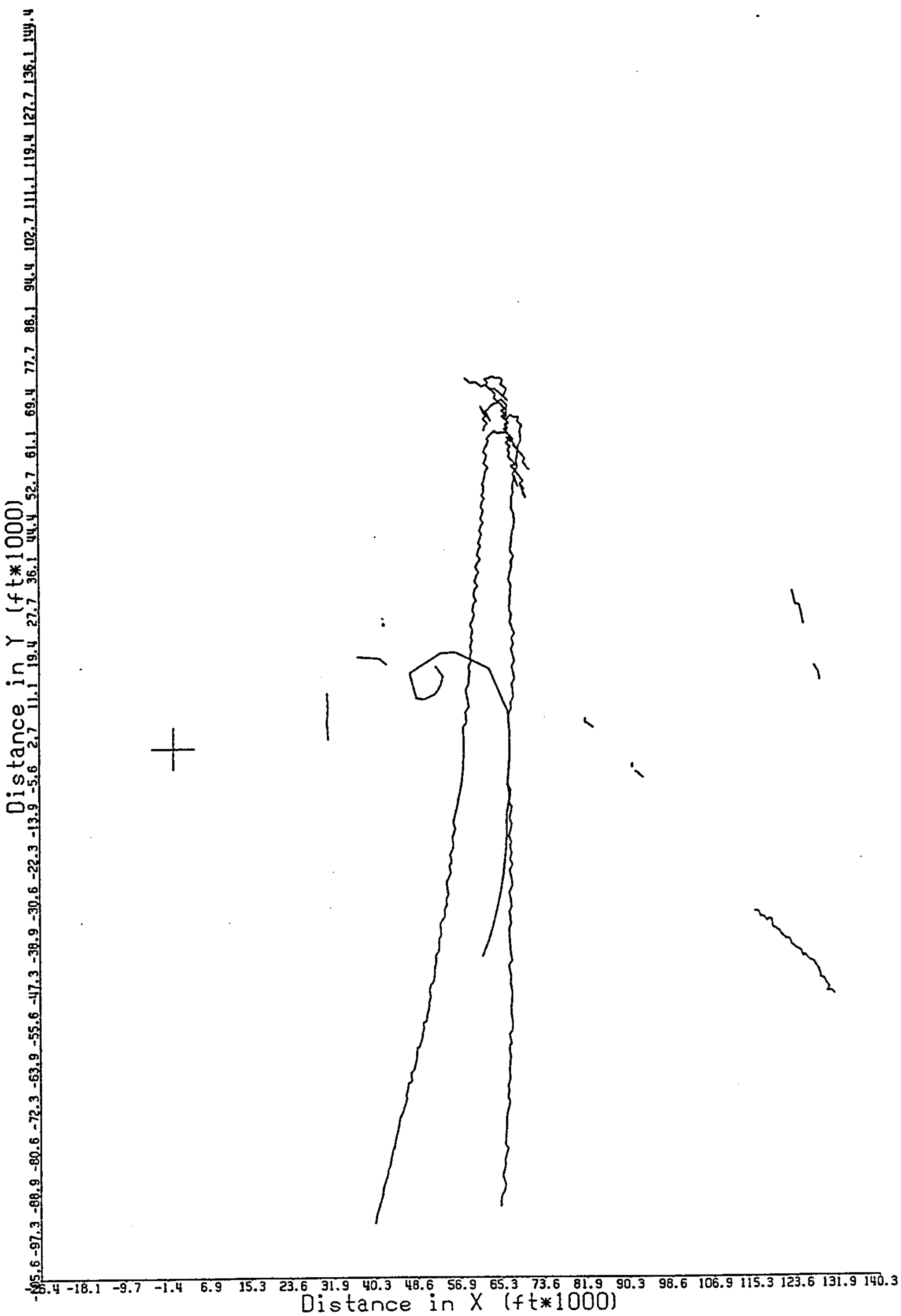


Figure D-16. H-60 Ground Tracks for Operations Between 2,000 and 5,000 Feet MSL.

APPENDIX E

Naval Air Warfare Center China Lake
Ground Tracks Recorded From Radar For the
Period Between 8 June 1994 and 16 June 1994

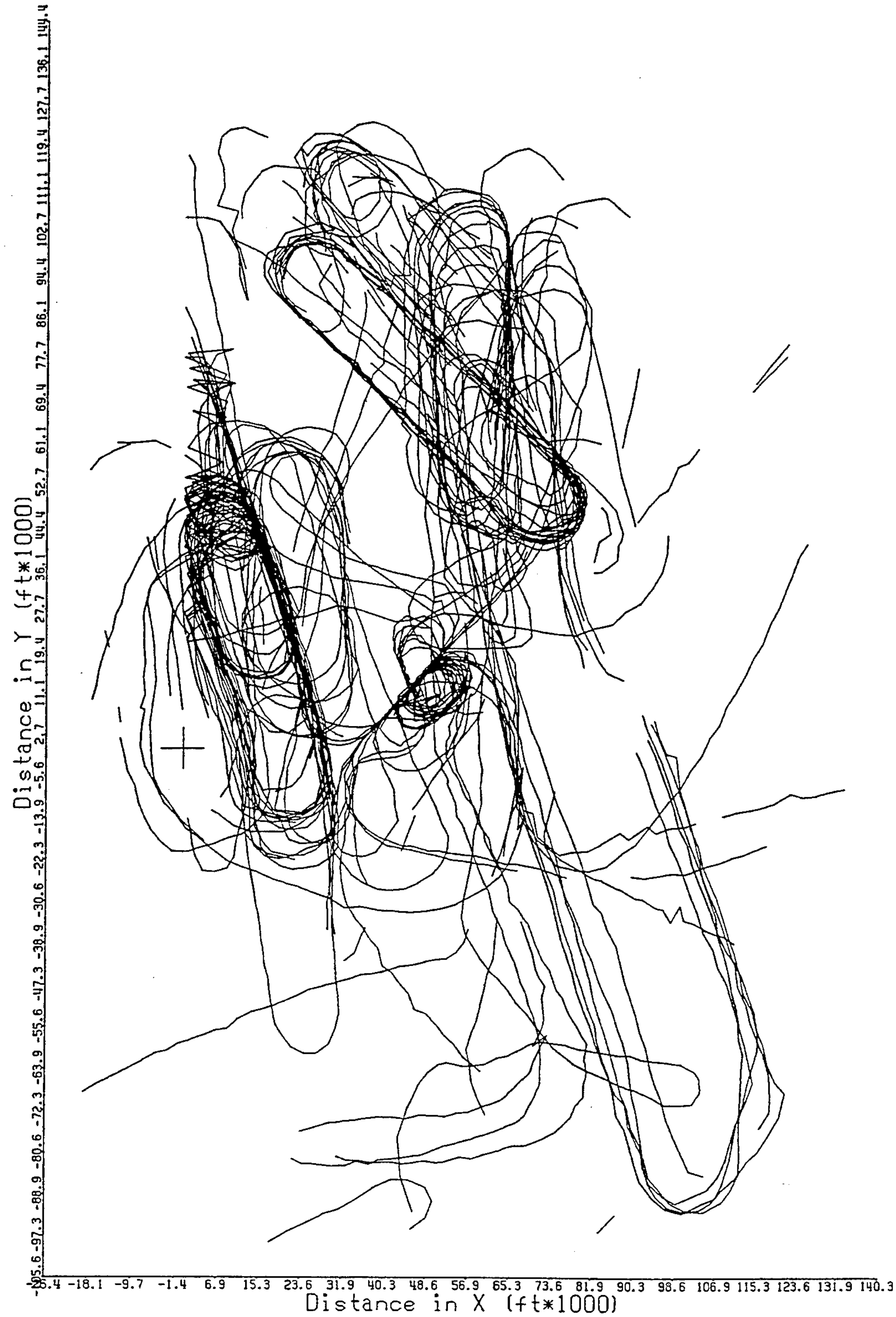


Figure E-1. F-18 Ground Tracks for Operations Between 2,000 and 3,000 Feet MSL.

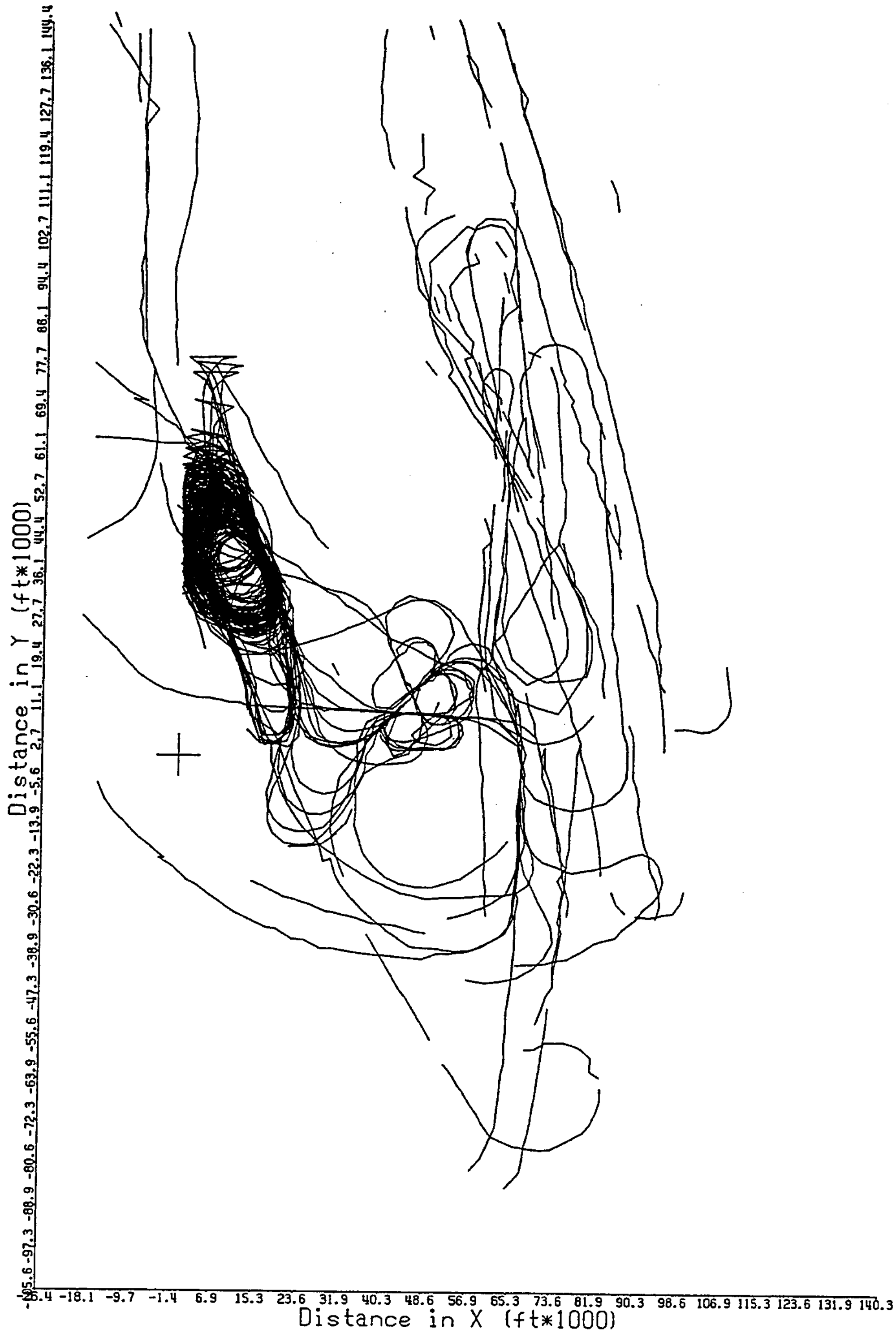


Figure E-2. AV-8 Ground Tracks for Operations Between 2,000 and 10,000 Feet MSL.

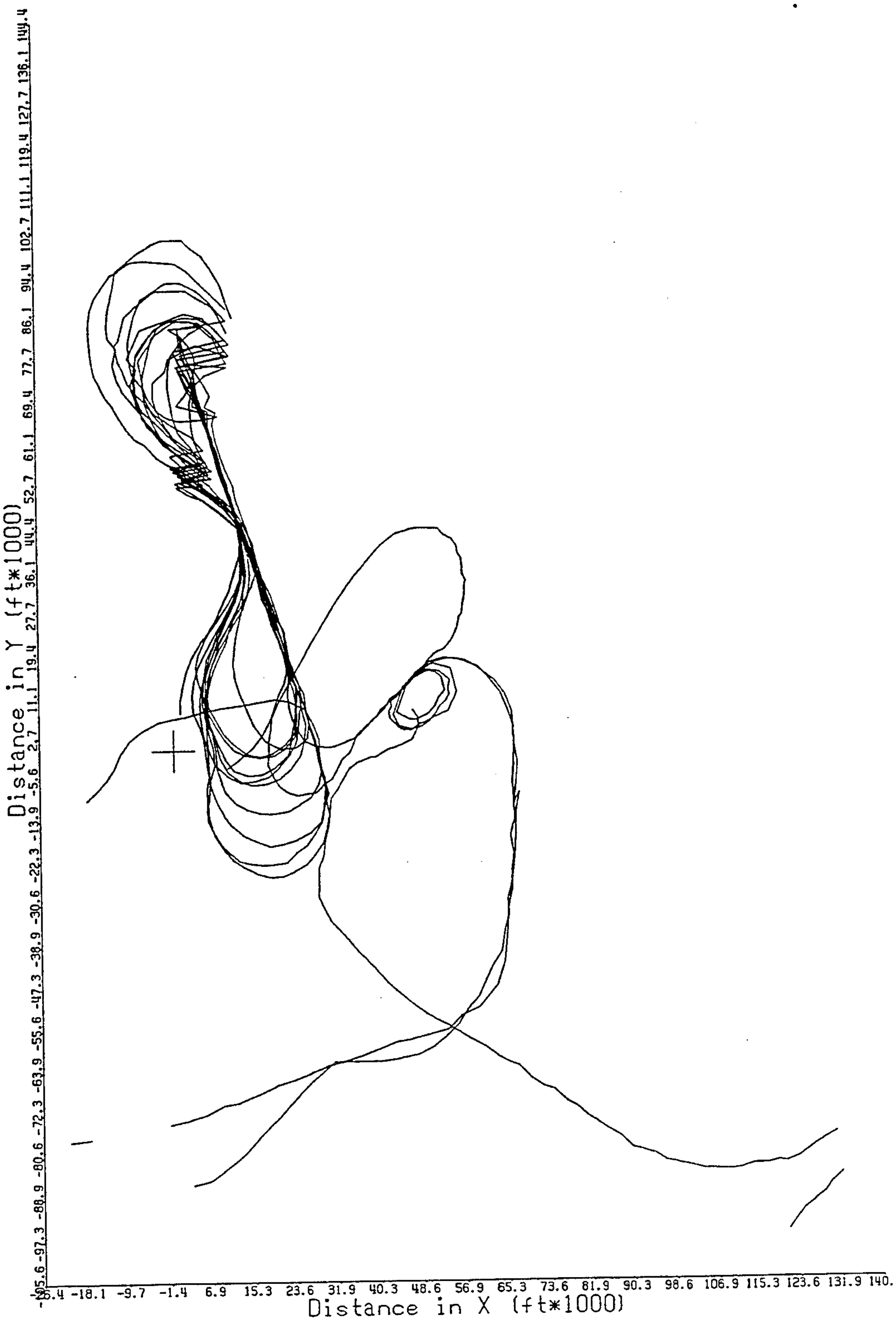


Figure E-3. A-6 Ground Tracks for Operations Between 2,000 and 10,000 Feet MSL.

APPENDIX F

Naval Air Warfare Center China Lake

Tracks and MOAs Used in MRNMAP

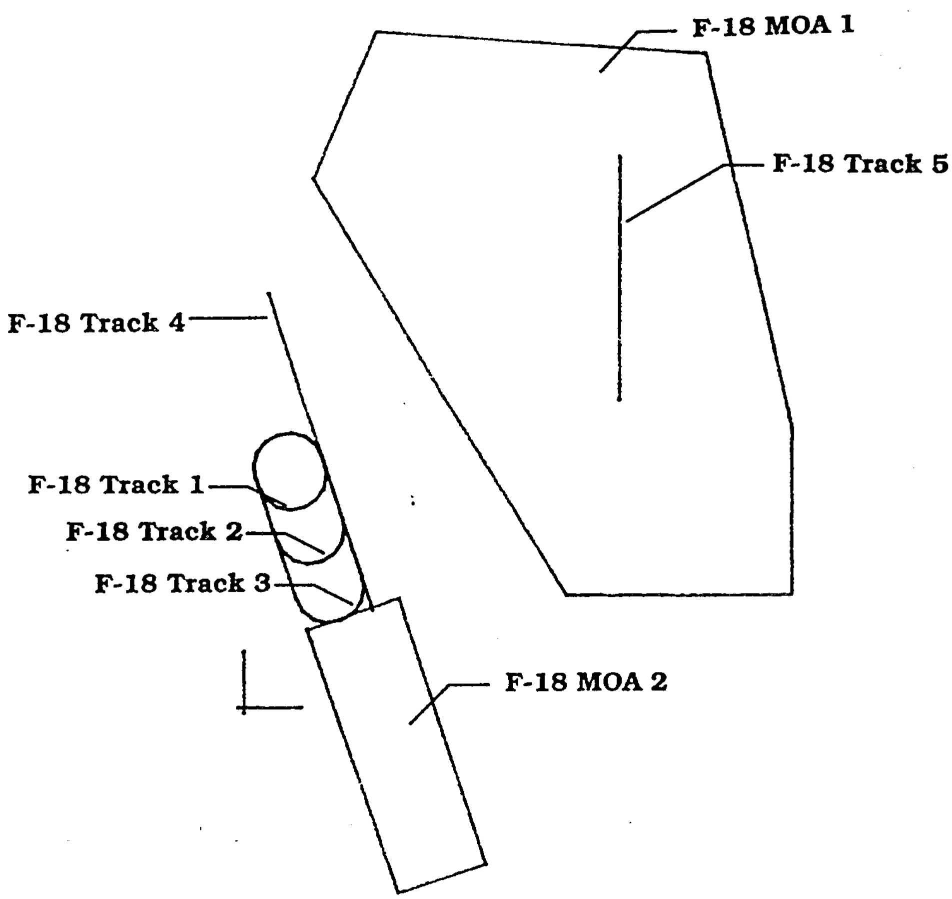


Figure F-1. F-18 Tracks and MOAs Used in MRNMAP to Model NAWC China Lake.

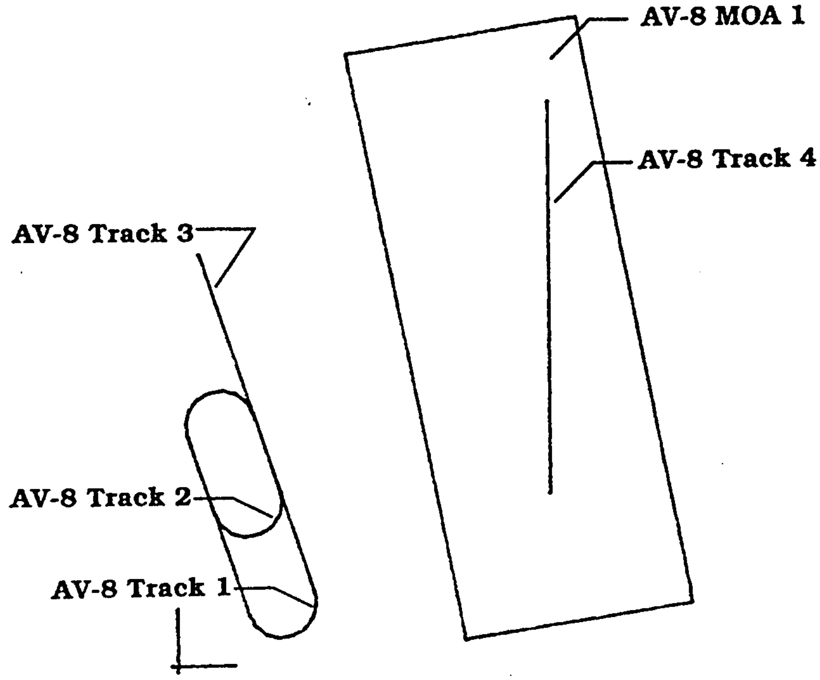


Figure F-2. AV-8 Tracks and MOAs Used in MRNMAP to Model NAWC China Lake.

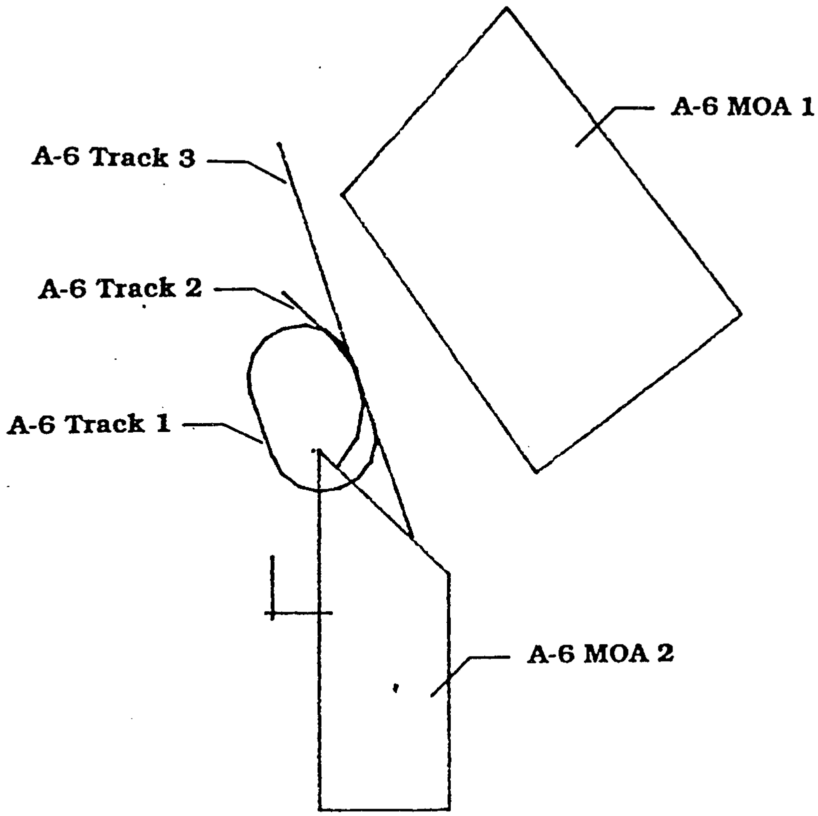


Figure F-3. A-6 Tracks and MOAs Used in MRNMAP to Model NAWC China Lake.

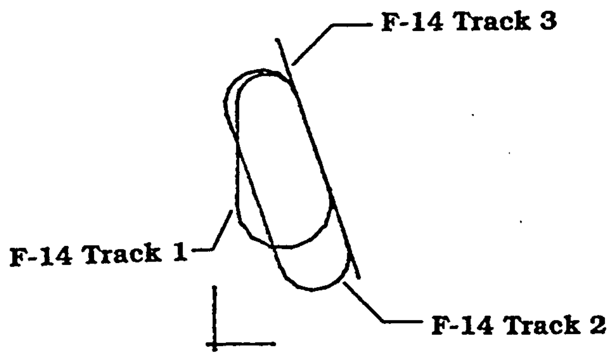


Figure F-4. F-14 Tracks Used in MRNMAP to Model NAWC China Lake.

APPENDIX G

Sample Test Cases

```
CNEL
SETUP PARAMETERS
0,1
1000
0,0
100000,100000
59,70,30
65
MISSION
P-3A
167, 180, 2000
1
100,100,100
TRACK SPEC
SAMPLE TRACK
5
LW       63867    38834    0        0        500
TW       30000    30000    0        0        2000     2000     10000    180
LW       24952    49352    0        0        2000
TW       58819    58186    0        0        2000     500      10000    180
LW       63867    38834    0        0        500
TRACK OPS
1
SAMPLE TRACK               100
1
P-3A     9000.0   3600.0   1800.0
END
.
```

```
SETUP PARAMETERS
4,0
1000
0,0
100000,100000
59,70,30
0
MOA SPEC
A MOA
4
20000,80000
40000,60000
60000,80000
20000,80000
100,18000
MOA SPEC
B MOA
5
60000,40000
80000,40000
80000,60000
60000,60000
60000,40000
100,18000
MOA SPEC
C MOA
9
20000,10000
40000,10000
40000,20000
80000,20000
80000,30000
40000,30000
40000,40000
20000,40000
20000,10000
100,18000
MOA SPEC
D MOA
5
50000,20000
60000,20000
60000,90000
50000,90000
50000,20000
100,18000
AVOIDANCE
3
A                   20000    40000    5000     2000
B                   40000    30000    5000     2000
C                   40000    14000    10000    2000
MISSION
F-16
127, 500, 84
1
500,500,100
MISSION
F-15
120,550,82
3
400,500,25
500,750,50
750,1000,25
MOA OPS
4
A MOA                        100
B MOA                        100
C MOA                        100
D MOA                        100
2
F-16      1000.0    0.0      0.0      10.0
F-16      1000.0    0.0      0.0      10.0
END
```